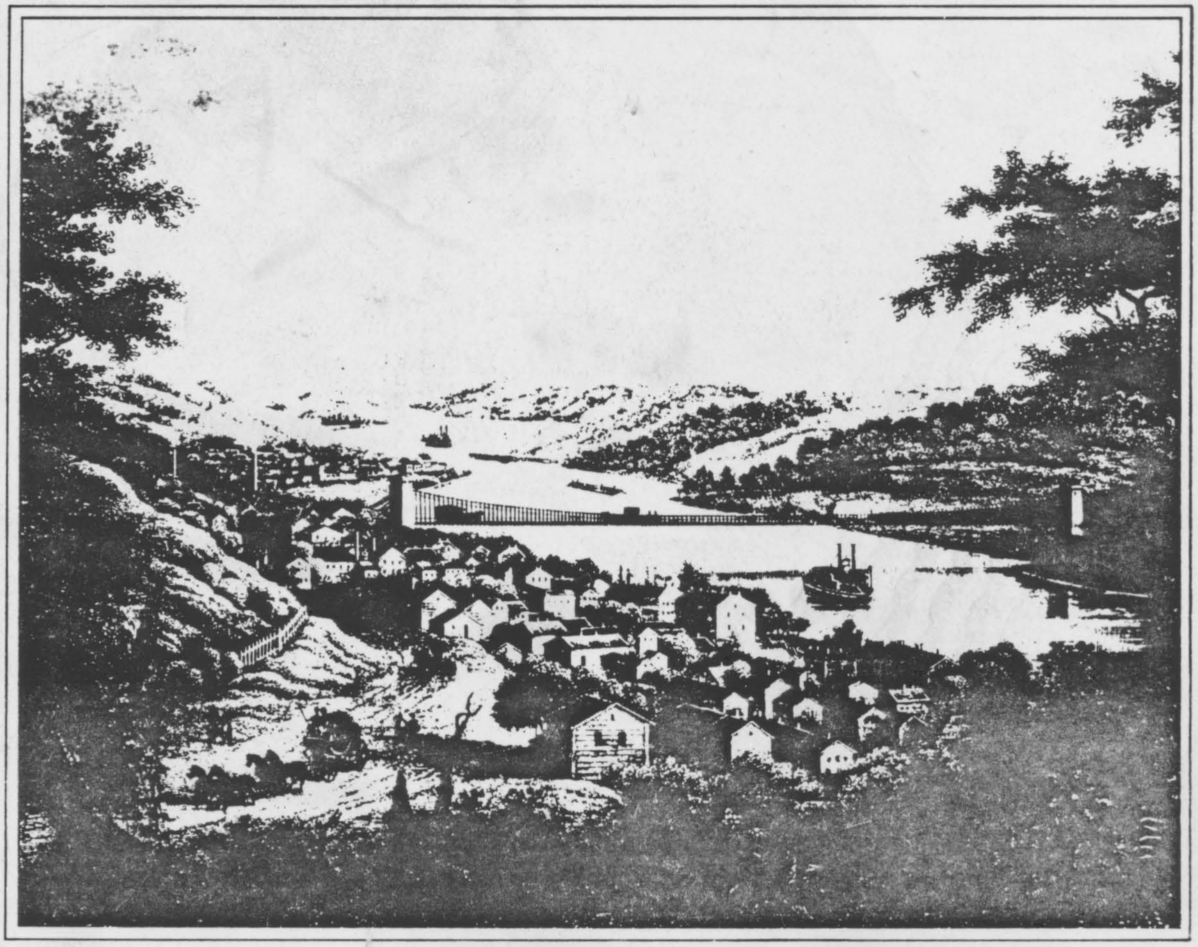
WEST VIRGINIA'S HISTORIC BRIDGES



WEST VIRGINIA'S HISTORIC BRIDGES

by

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for

West Virginia Department of Culture and History

West Virginia Department of Highways

Federal Highway Administration

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PREFACE

An historic bridge survey was initiated by the West Virginia Department of Highways and the Department of Culture and History to evaluate, categorize and rate highway bridges built prior to 1933 and owned by the Department of Highways in order to determine eligibility for the National Register of Historic Places. The survey was conducted by Dr. Emory Kemp of West Virginia University and financed by the Department of Highways, the Department of Culture and History and the Federal Highway Administration.

Sixty-three bridges from the survey were rated as being the most historically significant in West Virginia and were jointly selected by Highways and Culture and History to represent the state's cultural and engineering achievements prior to 1933.

The survey, which is Part II of this report, took two years to complete and involved inventorying more than 4,000 bridges. It will aid West Virginia's expanded bridge replacement and rehabilitation program by eliminating the need for Department of Highways evaluation of potential historic significance on a project-by-project basis, thus allowing continued project development.

ACKNOWLEDGEMENTS

This comprehensive study of historic bridges was a pioneering effort, not only with regard to the subject matter but also in terms of organization and sponsorship. Sponsors included the Department of Culture and History, Norman Fagan, Commissioner, and the Department of Highways, Charles Miller, Commissioner, representing state government, together with West Virginia University and the Federal Highway Administration. Each of these organizations has made a substantial contribution to this project. Seldom in the investigator's experience has a major project such as this been undertaken in such a noteworthy spirit of cooperation at all levels in each of the sponsoring agencies. The investigator is especially grateful for the assistance rendered by Rodney Collins and Michael Pauley of the Historic Preservation Unit; Bill Domico, Bob Smith, Don Stalnaker and Bill Harris of the Structures Division and Ava Zeitz, Ben Hark and Bruce Farrington of the Environmental Services Division, Department of Highways. At West Virginia University, Dr. Janet Kemp and Dr. Barbara Howe, historians, gave generously of their time and talents, as did Beverly Fluty, president of the West Virginia Independence Hall Foundation and a leading historic preservationist in West Virginia. The task of report preparation fell on the capable shoulders of Connie Hinzman and Irmgard Keiderling.

There are two individuals who should receive special recognition for their services, namely Roy Nuckles and Mark A. Kemp. Roy is in charge of the bridge archives for the Department of Highways, which

are kept in pristine order under his watchful eye. At best, the research was a disruption of the orderly routine of his office, since bridge files for entire districts were received for perusal by the investigator and later photocopying of pertinent information from each file. Roy provided computer printouts of the bridge listings and cheerfully supplied information when any questions arose. All of this was in addition to his assigned job.

Mark assisted at every phase of the study and quickly made himself indispensable by helping to organize both the office and field work into a manageable procedure. He accompanied the investigator on nearly all of the field work and spent many hours on data reduction and evaluations. His imprint can be seen throughout Part II of this report. In recognition of his contribution, this report is dedicated to him.

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PART I: HISTORIC PERSPECTIVES

> . . . . history consists essentially in seeing the past through the eyes of the present and in the light of its problems, and that the main work of the historian is not to record but to evaluate . . .[1]

Introduction

Bridges hold a particular fascination for many people as monuments to man the builder and as symbols of an earlier and simpler society often highly romanticized in the mind of the observer. One can almost see medieval knights or Roman legions crossing a strategic bridge en route to conquest or to perform exploits of valor. The observer need not travel nearly that far in either space or time to catch the romance of bridges because arguably the best example of this sentimental attachment to bridges is the Americans' delight and almost reverence for 19th century covered wooden bridges. Without really understanding their history, much less their structure, the public has had its imagination captured by these bridges as a symbol of craftsmanship associated with our bucolic past.[2]

For social and economic historians, the construction of bridges must be viewed in the context of a society bent on internal improvements, expansion and the exploitation of the nation's natural resources. In 1838 David Stevenson, an uncle of R. L. Stevenson and

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[1] Croce, B., History on the Story of Liberty (English translation), 1941, p. 19.

[2] The covered bridge is an outstanding example of the American craft tradition in building, but hidden in the hand-hewn wood members is the seed of a new engineering tradition based upon sound scientific principles.

a noted Scottish engineer, visited the United States and wrote with penetrating insight:

> The zeal with which the Americans undertake, and the rapidity with which they carry out, every enterprise which has the enlargement of their trade for its object cannot fail to strike all who visit the United States as a characteristic of the nation. English and American engineers are guided by the same principles in designing their works, but the different nature of the materials employed in their construction, and the climate and circumstances of the two countries naturally produce a considerable dissimilarity in the practice of civil engineers in England and America. At first view one is struck with the temporary and apparently unfinished state of many of the American works, and is very apt, before inquiry into the subject, to impute to want of ability what turns out, on investigation, to be a judicious and ingenious arrangement to suit the circumstances of a new country, of what the climate is severe--a country where stone is scarce and wood is plentiful and where manual labor is very expensive. It is vain to look to the American works for the finish which characterizes those of France, or the stability for which those of Britain are famed.[3]

Even at this early date, the social and economic influence was clearly manifest and in many ways has persisted in American technological and industrial development.

In an economic sense, the number, distribution and cost of bridge construction are important facts necessary to understand the history of American transportation. On the other hand, since bridge construction and maintenance were the responsibility of local or county authorities, they became great social enterprises. They were not simply financed by local funds but, as we shall see later in this text, were often built by local builders. Even in the prefabricated era of bridge building, the piers and abutments were

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3 Stevenson, David, Sketch of the Civil Engineering of North America, Wesle, London, England, 1838.

the responsibility of local stone masons, and often the superstructure was erected by local semi-skilled labor.

Bridge building was an intense human activity, and thus the social and economic facets of bridge building should not be neglected in the history of bridges. These factors are important in their own right but, in a larger sense, it is clear, in the case of bridges, the powerful influence social and economic factors have on technology.

The history of technology--and especially that aspect of the subject concerned with large-scale civil engineering work--has a long biographical tradition which tends to laud the lives of leading engineers and their monumental works. At its best this tradition has sought to answer questions about the origin of structural ideas, the influence of new materials and technical demands, and construction methods on bridge building. On the other hand, this tradition has often produced history on a heroic scale quite out of context with the status of the profession, industrial capacity or the society which made these great works possible. It is rather like writing military history in terms of the lives and tactics of the field marshals of the opposing sides with little recognition of the men who did the fighting or the industry which produced the weapons. Interestingly, leading Victorian engineers have been referred to by Clark, et al. as the great field marshals of the industrial revolution, directing armies of "navvies" [4] in a

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[4] The origin of the term navvy is obscure. Some credit it to James Brindley, the famous early canal builder in England, who is reported to have misspelled the word navigator. In any case, the early canals in England were called navigations and the men who built them were navigators or navvies.

battle to subdue nature to the purposes of mankind. It was quite heady stuff and gave rise to what a number of Victorian authors called the romance of engineering.[5]

Sir Samuel Smiles was really the founder of this heroic tradition and his Lives of Engineers[6] was both popular and strongly influenced the way people viewed technology. Because of Smiles' particular view of history, his writings served also as a form of moral instruction. He was the chief proponent of the doctrine of self-help. The following inscription, which appears on an early 19th century pottery jug, epitomizes this position:

> Work on Hope on
> Self Help is noble schooling
> Always do your best and leave the rest
> To God Almighty's ruling

No wonder Lord Acton, who later in the century produced the monumental Cambridge Modern History,[7] was an advocate of "wie es eigentlich gewesen" or, as Harry Truman used to say, "tell it like it is." In other words, the historian's chief duty is to produce the facts and let them speak for themselves. This was, in Acton's judgement, the only way to avoid moralizing history. Between these two rather extreme positions, modern historians try to avoid moralizing but view their primary duty as one of evaluating and

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[5] Clark, Sir Kenneth, Civilisation, Harper and Row, New York, 1969.

[6] Smiles, Sir Samuel, Lives of Engineers, London, 1862.

[7] Acton, Lord John E.E., Lectures on Modern History, MacMillan & Co., Ltd., London, 1906; reprinted by Meridian Books, Inc., New York, 1961.

interpreting historical facts. The question of historiography or the "history of history" must be answered if historians are to avoid being mere antiquarians. In reviewing a new book, After the Fact, the Art of Historical Detection, Time magazine gives a succinct description of what modern historians do as professionals:

> Historians are not simply messengers in time, bearers of immutable facts. For better or worse, (they) inescapably leave an imprint as they go about their business: asking interesting questions about apparently dull facts, seeing connections between subjects that had not seemed related before, shifting and rearranging evidence until it assumes a coherent pattern. The past is not history; only the raw material of it 8

Although the biographical tradition in the history of technology still flourishes, recent historians, in attempting to explain the rise of our modern technological society, have moved from a rather simple view of the subject as manifest in self-help or economic determinism to seeing the subject as one of considerable complexity. Since World War II, industrial archaeologists have been providing historians with information obtained from site investigations to supplement the traditional archival source of historical information. This archaeological evidence is the first step in preserving historic structures, since the record is preserved and this information is of use not only to historians but to those interested in preserving or restoring historic structures, including historic bridges.

In the 19th century, architects were preoccupied with monumental architecture utilizing traditional materials such as stone and

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8 Time book review, reprinted in Review, The History Book Club, May 1982, page 25.

brick. Their chief concerns were twofold, namely a philosophical understanding of the meaning of architecture based on a revival of styles from the past and a commitment to the accuracy of the details used, rather than a primary concern for aesthetics. The philosophical question led to a battle of styles--classical vs. Gothic--in the context of the Romantic Movement. Little wonder that even such important buildings as the Crystal Palace of 1851 and monumental engineering works were dismissed from serious consideration by declaring them to be non-architecture. As a result, architects were unable to relate to the urban industrial society rapidly developing around them. It is now apparent that many of these structures, which were not thought worthy of the name, are of considerable architectural merit.

The history of civil engineering has also suffered from a narrow view, as indicated above, resulting in a neglect of an important chapter in the history of bridges by concentrating on the lives of leading engineers and their monumental long-span bridges as opposed to myriad medium- and short-span bridges built by little-known bridge builders and later by engineers to serve local needs.

Ironically, in many ways monumental bridges are direct descendants of a pre-industrial tradition. They represent "bespoke" tailoring versus ready-made clothing, since they were individually conceived, designed and constructed for a particular site. The approach that took advantage of the industrial climate in the United States was that of new bridge companies established after the Civil War, which developed standardized bridge designs and produced

complete bridges in large fabricating shops. These bridges were sold by the thousands across the length and breadth of the nation by aggressive bridge salesmen who appeared before county courts, city councils and other potential public and private clients, promoting their bridges with the help of catalogues. Thus "catalogue bridges" appeared on the scene after the Civil War and became a ubiquitous feature on the American landscape. Arguably, they had a more profound effect on the development of the American highway system than the justly famous landmark bridges by such luminaries as Roebling, Eads, Cooper, Ellet, et al. Catalogue bridges are an important but much-neglected chapter in the history of technology. As will be seen, this was a local self-help method which was an intensely human activity, involving whole communities and local government.

The recently completed study of the historic bridges of West Virginia can be used as a case study to describe the history and art of bridge building in the 19th and early 20th centuries. Using examples of Mountain State bridges is not intended to be provincial but to be representative of the technological changes and advances which were taking place in most of the eastern states.

Many of the improvements in transportation caused by the western expansion occurred in West Virginia, where examples of the changing technology in bridge building can be found. Western Virginia was the scene of early 19th century construction of turnpikes such as the Northwestern, Staunton to Parkersburg and James River and Kanawha. The most significant early road, the National Road, was

not a turnpike (i.e., a toll road) in its early days (see Figure 1). It was the first "interstate" road financed by the federal government and featured many important civil engineering works, including the first cast-iron arch bridge in America at Brownsville, Pennsylvania, and some of the earliest stone arch bridges in the region, to say nothing of the Wheeling Suspension bridge, one of the world's great bridges (see Figure 2).[9]

America's pioneering railroad was the Baltimore and Ohio Railroad, whose main stem stretched nearly 400 miles between Baltimore and Wheeling. It was a leader in developing the all-iron railway truss, with major bridges constructed at Harpers Ferry and Fairmont (see Figures 3 & 4).[10] These transportation arteries were internationally significant and had a profound influence on bridge technology, including the later patented types which characterize the "catalogue bridge." West Virginia will be used as a case study to trace the evolution of bridges from the first timber and stone bridges of the turnpike era through the early pioneering, flourishing and mature phases of metal and concrete bridges. Apart from a limited number of long-span bridges, the focus will be on bridges built on early turnpike roads and, later,for county courts and other local authorities. Emphasis will be placed upon the

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9 Searight, Thomas B., The Old Pike, 1894; reprinted by Green Tree Press, Orange, Virginia, 1971. The most complete account of the National Road, it is more of a social history than an account of the technology of road building, but is nevertheless a valuable reference.

10 Hungerford, Edward, The Story of the Baltimore and Ohio Railroad, G.P. Putnam & Sons, New York, 1928. The standard work on the subject gives a general treatment of the building of this early railway.

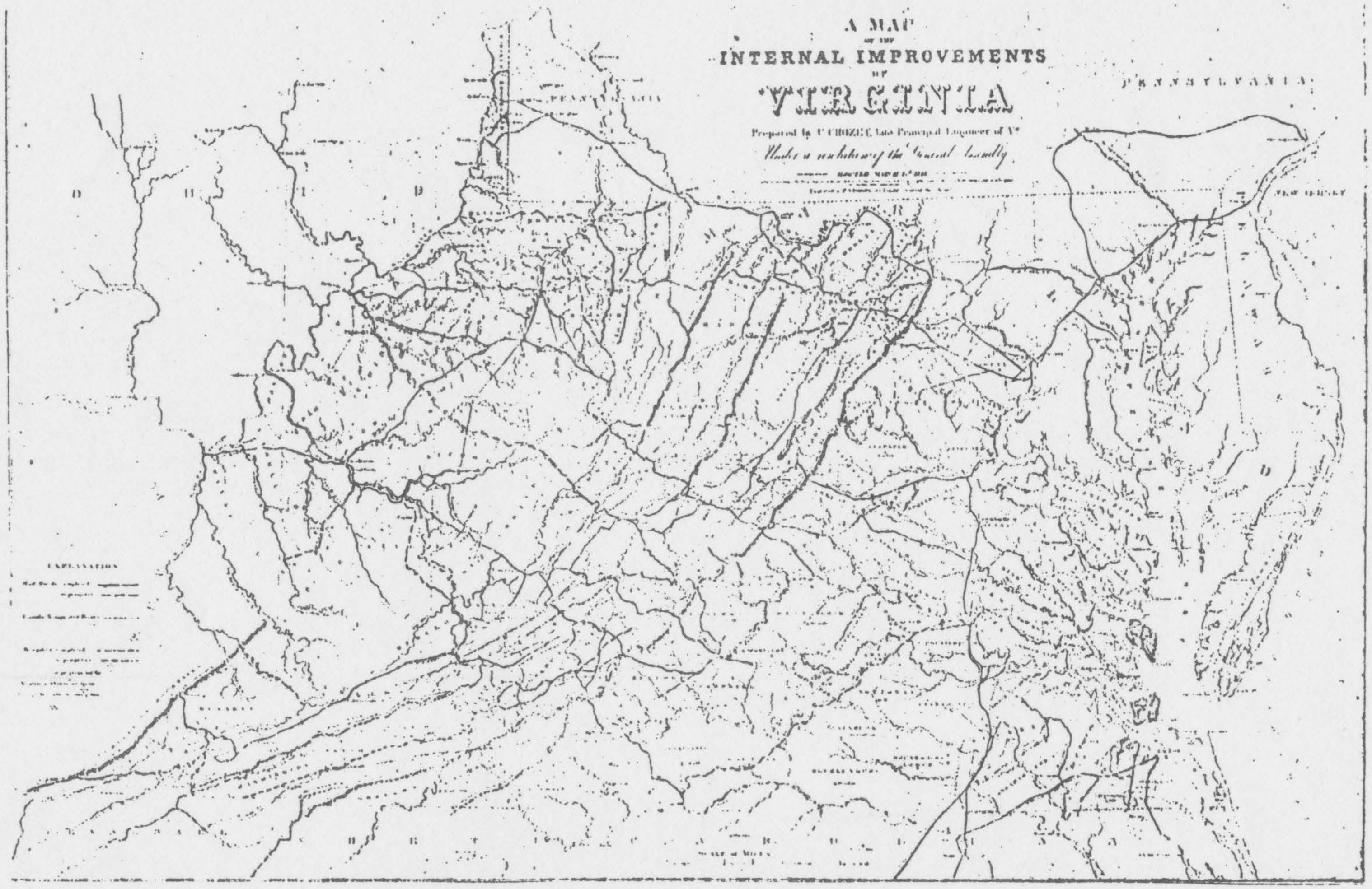

Figure 1. Crozet's 1848 Turnpike Map

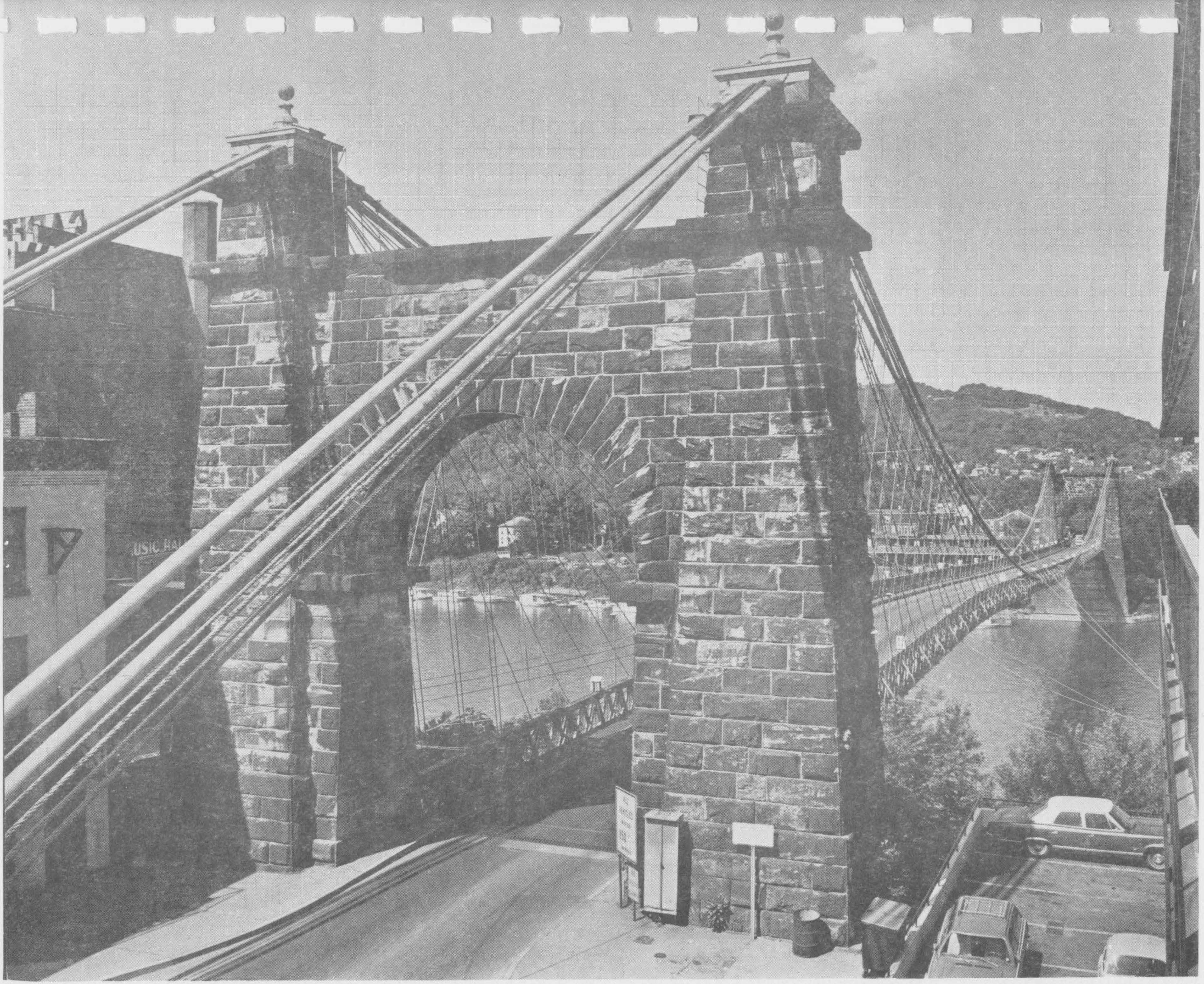

Figure 2. Wheeling Suspension Bridge, 1849 - William E. Barrett

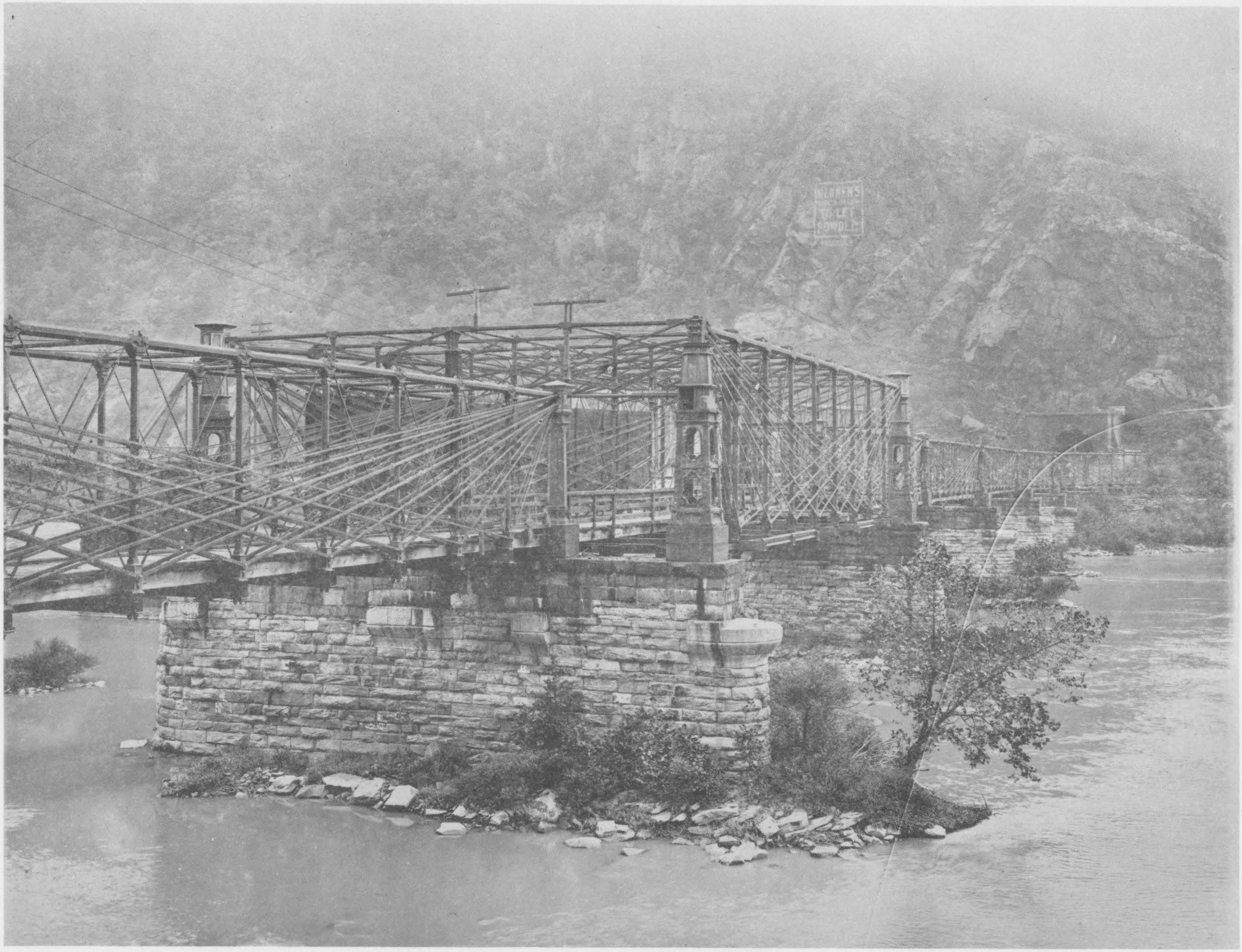

Figure 3. Bollman's Bridge at Harpers Ferry - Smithsonian Collection

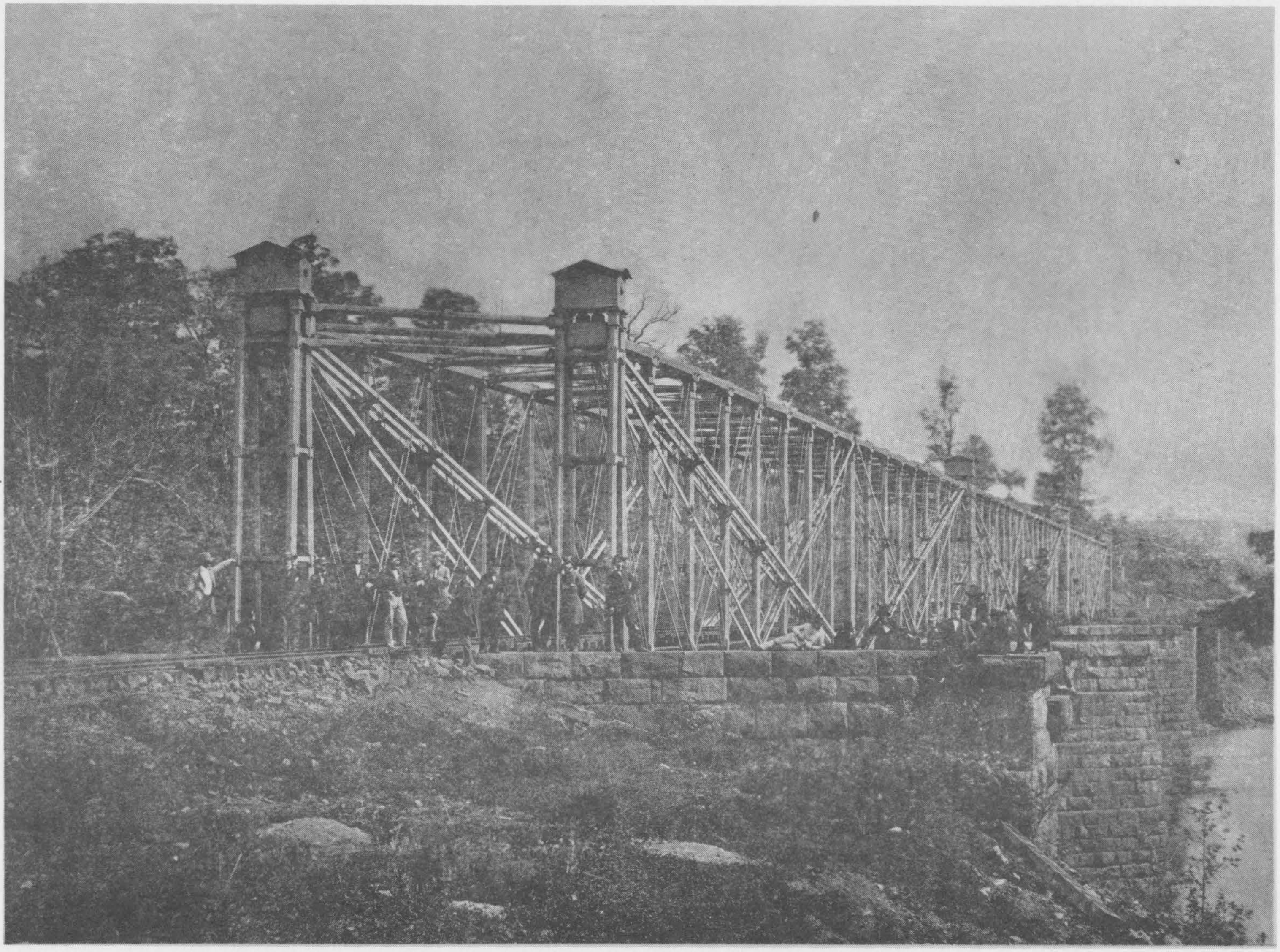

Figure 4. Fink's Great Iron Bridge at Fairmont - Smithsonian Collection

interrelationship between leading technological advances, represented in major structures such as the Wheeling Suspension bridge, and a legion of "catalogue bridges," numbering more than 4,000 extant in West Virginia, ranging in date from 1817 to the end of the local/county system in 1933. For general historical information on 19th century bridges, the reader is referred to the selected bibliography in Appendix A.

The Turnpike Era

The early roads in Virginia, following the routes taken by the first settlers in the western part of the state, were merely trails blazed by frontiersmen or Indians. After the Revolutionary War, new roads and the repairing of old roads were under the aegis of the county courts, which could apply to the General Assembly for help in building major works such as bridges. Road building proved too costly for counties alone, and the legislature authorized the construction of toll roads where, it was hoped, tolls would pay for the cost of the road and its later maintenance.[1]

In 1772 the Virginia legislature authorized the first toll road, between Jenny's Gap and Warm Springs in Augusta County. One of the early and most successful toll roads, the Little River Turnpike was chartered in 1811. In the early days of the turnpike, the General Assembly provided some of the money and the rest was raised by lottery. Joint stock companies were a later development. The number of turnpikes constructed in Virginia between the end of the Revolutionary War and the General Turnpike Act of 1817 was very small.

There was no comprehensive plan for building roads to complement the growth and development of the state. Attention was drawn to the need for such an overall plan by a famous report on roads and canals delivered to the United States Senate in April 1808 by Albert

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[1] Kemp, Emory L. and Janet, "Building the Weston & Gauley Bridge Turnpike," West Virginia History, Vol. LI, No. 4, Summer, 1980. This paper gives general information on turnpike construction in antebellum Virginia as well as specific information on the Weston and Gauley Bridge Turnpike.

Gallatin.[2] Gallatin, who was Secretary of the Treasury, believed that it was in the best interests of the new nation to have a comprehensive transportation plan to facilitate trade and develop the country: "good roads and canals will shorten distances, facilitate commercial and personal intercourse and unite, by a still more intimate community of interests, the most remote quarters of the United States." Gallatin proposed a plan to improve connections between the Atlantic seaports and to link these ports with the Great Lakes and the western waterways by reaching the Ohio River. He felt that so great a plan as his could only be accomplished by the federal government, since there was simply not enough private capital to accomplish so ambitious an enterprise and the population of the United States was spread so thinly. He felt that good transportation was, however, necessary for the good of the nation: "No other single operation within the power of Government can more effectively tend to strengthen and perpetuate that Union which secures external independence, domestic peace and internal liberty."

The main emphasis in his report was upon canals, which were at the time the most advantageous means of transporting goods over any distance. Roads were secondary to the canals and were to be built as links where it was not feasible to build canals. The interest in canals was reflected in Virginia's early legislation and continued support to canal companies at the expense of railroads, especially

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2 Gallatin, Albert, Report...on the Subject of Public Roads and Canals, 1808; reprinted by Kelley, New York, 1968.

the James River and Kanawha Canal.[3]

By the time of Gallatin's report, the population of Virginia had increased considerably and a greater part of the state was permanently settled. The need for adequate transportation was quite apparent, and in 1816 the Virginia General Assembly created the nation's first Board of Public Works and Fund for Internal Improvement. This provided for the establishment of joint stock companies, using both public and private capital. The principal function of the Board of Public Works was to supervise the internal improvements of the state. The Board assessed the merits of various turnpike proposals, examining the location, construction methods, costs, etc., and recommended to the legislature that certain private companies be chartered. The Board also administered the state funding for these turnpike companies. The turnpike companies were required to report annually to the Board of Public Works on the progress of their work and the Board, in turn, made an annual report to the General Assembly. The Board of Public Works, however, had no authority or power to plan or build roads, but was only to advise the legislature and to supervise such building as the legislature had authorized. This meant that there was no centralized plan for road building in the state, and the roads which were built resulted from local initiative, regardless of whether they satisfied the

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3 This state-supported internal improvment scheme was never completed, yet occupied the interest of the General Assembly for more than two decades. Large sums were spent on its construction despite advice by such eminent engineers as Claudius Crozet against pursuing the project. Preoccupation with the canal prevented Virginia from encouraging road and rail systems in what is now West Virginia.

transportation needs of the state as a whole. As a result, in the first 40 years of the 19th century, most of the turnpikes in Virginia were built in the eastern part of the state.

In the western part (now West Virginia), the population was too small to raise the necessary capital for a turnpike. After 1840 there was a marked increase in turnpike companies chartered in western Virginia. It must be noted that, at this time, numerous railroad companies were chartered in eastern Virginia. The turnpike as a means of transportation was being eclipsed by the railroad, and western Virginia was again neglected in this respect, a situation noted at the time by discontented western Virginians.

The weaknesses of the Board of Public Works in providing for the comprehensive transportation needs of the state were clearly felt by its most famous chief engineer, Claudius Crozet (1790 - 1864), who was often at odds with the General Assembly. Captain Crozet had been a French artillery officer under Napoleon. After the battle of Waterloo he left Europe, in 1816, for the United States. He served as a professor of engineering at the U.S. Military Academy at West Point, New York, until 1823, when he became the principal engineer of the Virginia Board of Public Works. He served in this capacity from 1823 to 1831 and again from 1838 to 1843. The break in his service was a result of his disagreement with the General Assembly. An early advocate of railroads, he proposed a railroad to link the eastern and western parts of the state. The influential members of the General Assembly favored canals and, after a reorganization of the Board of Public Works, Crozet resigned. Later, as the state

recognized the use of steam locomotives, Crozet was reinstated as principal engineer until 1843, when the office was abolished. He continued to serve the state as a consultant.

The job of chief engineer was not an easy one, but Crozet accomplished a great deal in improving transportation in Virginia. He was responsible for two major east-west routes to link the two parts of the state, the James River-Kanawha Canal and the Northwestern Turnpike. Crozet and his engineers conducted surveys throughout the state to determine the feasibility of roads. The private turnpike companies chartered by the General Assembly were responsible for the actual building of the roads, and Crozet was often critical of these roads. His advice, with regard to location, alignment, width or construction, was often ignored by the companies, leaving him critical of the resulting roads. He was also very conscious of the need for accurate surveys and maps of the state to assist in the location of new roads. However, he had great difficulty in persuading the General Assembly to provide the means to achieve a satisfactory map. Although he did produce several maps for the state, the most notable in 1848, he was dissatisfied with the results and continued to urge the need for an adequate map. On the whole, legislators failed to appreciate his concern.

With the interest in turnpikes at the beginning of the 19th century resulting in establishment of the Board of Public Works, the Virginia General Assembly passed a General Turnpike Act in February 1817 to regulate the incorporation of turnpike companies and set forth general regulations for them. The first part was concerned

with the raising of stock. After the subscription books had been opened and the public notified, half of the said capital had to be subscribed before the company could be declared incorporated. To transact the business of the company, the subscribers then could elect a president and five directors, who were empowered to buy any land necessary for the road. If a landowner would not agree, county courts would settle the matter and award the landowner damages. Regulations for the road itself were as follows: the road must be 60 feet wide, 18 feet of it well-graveled; a summer or side road 18 feet wide was to be kept in good repair. Every five miles a toll gate could be erected. Maximum weights were given for wagons according to the width of their wheels--the wider the wheels, the larger the weight the wagon was allowed to carry--and scales were to be erected to check these weights. Tolls were fixed at six and one-half cents for a score of sheep or hogs, 12 and one-half cents for a score of cattle, six and one-fourth cents for each animal drawing a cart or wagon whose wheels were less than four inches, three cents for each animal drawing a cart or wagon with wheels greater than four inches but less than seven inches and one cent for each animal drawing a cart or wagon with wheels greater than seven inches. Troops and public state property were exempted from tolls. Subscribers had to hold an annual meeting and the road had to be kept in good repair. If the directors failed to keep it in good repair, the local magistrate could suspend tolls. Persons using the road were instructed to drive on the right-hand side. Road construction had to begin within two years from the date of

incorporation and be completed within ten years.

All subsequent acts incorporating turnpike companies were bound by the regulations of this act, except for provisions which were specifically stated. The interest in building turnpikes was high and many companies sought charters. The greatest difficulty these companies faced was raising sufficient funds from private investors before actual work could be done and before the state would contribute its share (the private portion of 20 percent had to be collected before the state would contribute). Out of 647 companies chartered by the state, less than 30 percent became operating companies, and very few of these even made enough money to operate successfully.

When a company had enough money, it could begin road construction, with actual construction of the road varying from company to company. The 1817 Act simply specified that the road should be cleared for 60 feet, of which at least 18 feet should be covered with gravel. In the western part of the state, where road builders encountered numerous difficulties, the width of the road was often reduced and the summer or side roads dispensed with altogether. Some turnpikes were no more than improved dirt roads, while others were macadamized and constructed with elaborate drainage systems.

There were several manuals of road-building practices available to road builders early in the 19th century. Most experts agreed that a good dirt road was adequate for all kinds of vehicles but, in order to keep the dirt road in good condition, it had to have some

sort of covering to keep the road dry and provide a smooth surface for vehicles. The gravel and stone which were put on the roads were not viewed as the road itself, but simply a protective coating. The method by which the coating was applied and the materials of which it should consist were the subjects of great debate. Basically, two methods were advocated, as proposed by McAdam and Telford, two leading British engineers.

For the most part turnpike bridges were very humble structures in the form of simple trestles or basic short-span queen post trusses, which were left uncovered (see Figures 5 & 6). The following is an excerpt from the Slavin's Cabin and Summersville Turnpike specifications, describing the typical bridge used in western Virginia during the turnpike era:

> For large bridges plans and specifications will be furnished; they are not to make part of the road sections. But the common bridges not exceeding 40 feet will be included in the contract for the sections they belong to.
>
> They must be made 18 feet wide in the clear for a double track, and only 12 feet if only one track is required. This last dimension will be understood to be intended when not otherwise specified.
>
> The abutments, when needed, to consist of dry masonry, laid carefully on a firm foundation; the first course of stones to be large and flat, and the other courses to consist of a due proportion of headers and stretchers, there being at least one header in every five feet of the face of each course, and each header corresponding to about the middle of the interval of the headers of the preceding course, and projecting at least one foot and a half back of the stretchers, and none of the latter to be less than six inches high and one foot thick, nor longer than four times its height.
>
> The average thickness of the abutments and wings shall not be less than one-fourth of their height, and nowhere under 18 inches. The outside batter shall not exceed two inches to one foot. When the length of the bridge is subdivided into small spans and trestles are used, they must consist of three of four uprights (according to the width) to be laid at equal distances from each other, the sleepers being 8 inches by 12. Their ends to rest either on sills at least 12 inches square, inserted

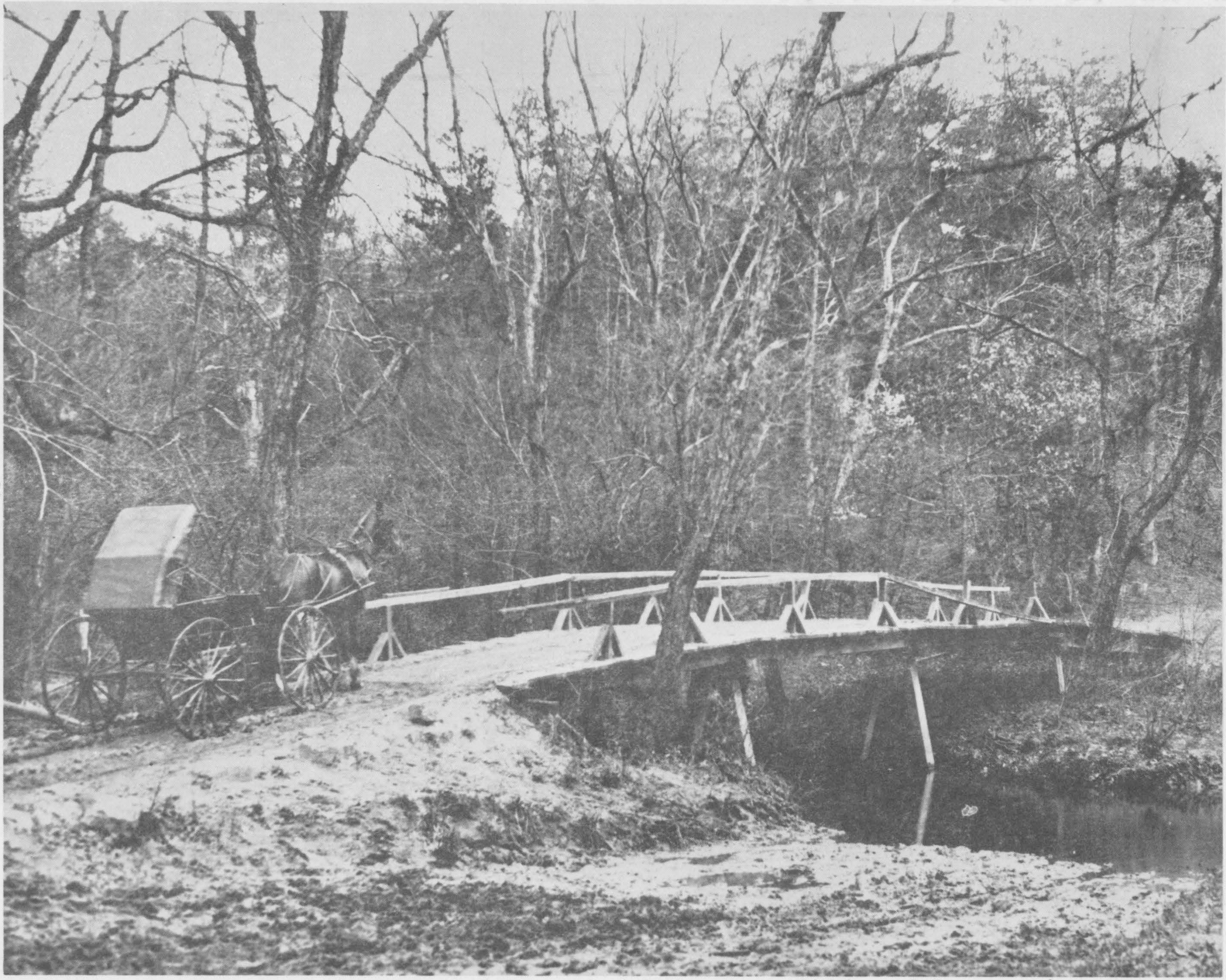

Figure 5. Typical Turnpike Bridge - Virginia Department of Highways & Transportation

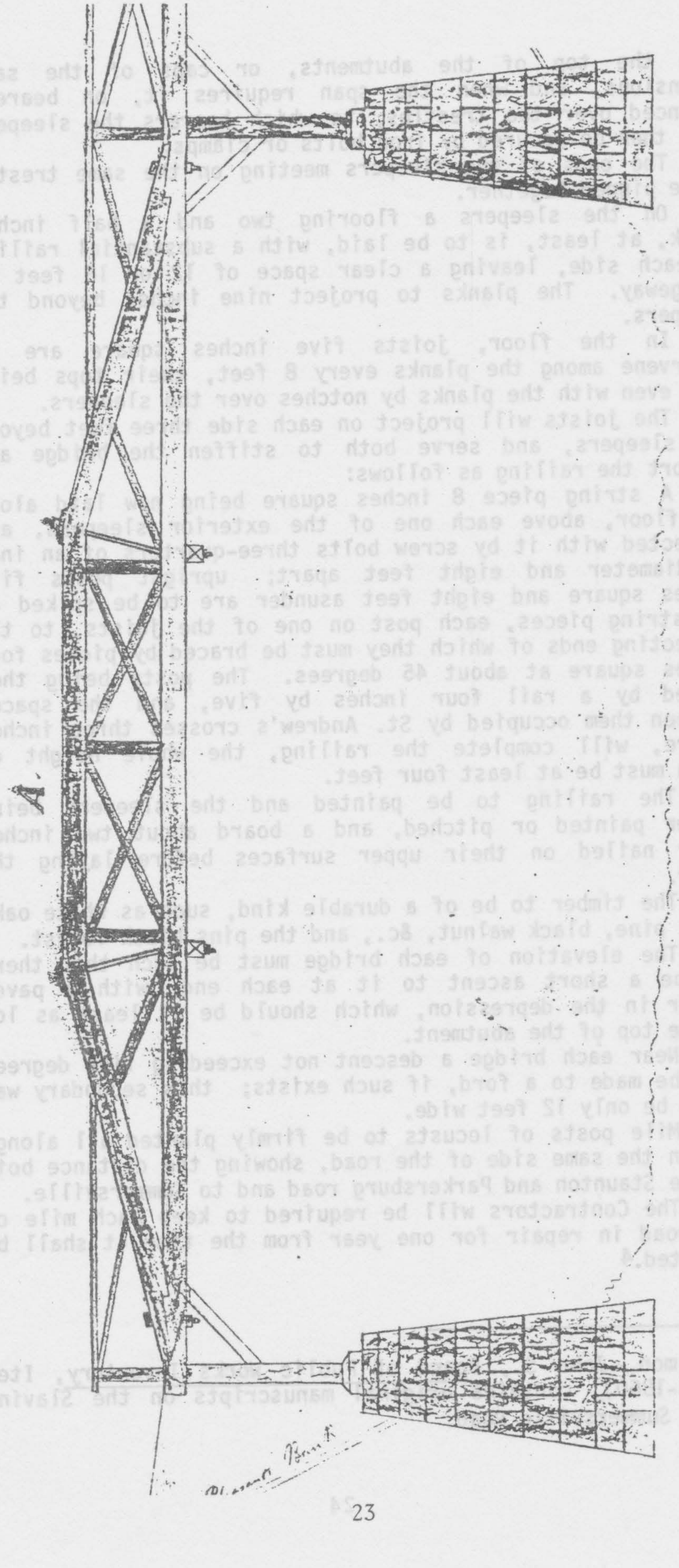

Figure 6. Typical Turnpike Bridge near Parkersburg

into the top of the abutments, or caps of the same dimensions, and when the span requires it, on bearers balanced over the trestles, to which bearers the sleepers must then be secured by iron bolts or clamps.

The ends of the sleepers meeting on the same trestle to be pinned together.

On the sleepers a flooring two and a half inches thick, at least, is to be laid, with a substantial railing on each side, leaving a clear space of 12 or 18 feet of bridgeway. The planks to project nine inches beyond the sleepers.

In the floor, joists five inches square are to intervene among the planks every 8 feet, their tops being made even with the planks by notches over the sleepers.

The joists will project on each side three feet beyond the sleepers, and serve both to stiffen the bridge and support the railing as follows:

A string piece 8 inches square being now laid along the floor, above each one of the exterior sleepers, and connected with it by screw bolts three-quarters of an inch in diameter and eight feet apart; upright posts five inches square and eight feet asunder are to be spiked on the string pieces, each post on one of the joists, to the projecting ends of which they must be braced by pieces four inches square at about 45 degrees. The posts being then capped by a rail four inches by five, and the spaces between them occupied by St. Andrew's crosses three inches square, will complete the railing, the whole height of which must be at least four feet.

The railing to be painted and the sleepers being either painted or pitched, and a board about two inches wider nailed on their upper surfaces before laying the floor.

The timber to be of a durable kind, such as white oak, heart pine, black walnut, &c., and the pins black locust.

The elevation of each bridge must be such that there may be a short ascent to it at each end, with a paved gutter in the depression, which should be at least as low as the top of the abutment.

Near each bridge a descent not exceeding five degrees must be made to a ford, if such exists; this secondary way is to be only 12 feet wide.

Mile posts of locusts to be firmly planted all along, and on the same side of the road, showing the distance both to the Staunton and Parkersburg road and to Summersville.

The Contractors will be required to keep each mile of the road in repair for one year from the time it shall be accepted.[4]

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[4] Salmon, John S., Board of Public Works Inventory, Item 392 (1853-1860), contains original manuscripts on the Slavins Cabin and Summersville Road.

Following the Civil War, the turnpike system was disbanded and the roads returned to local service. The opening of the railroad system provided the only efficient transportation network for both passengers and freight. It was not until the 20th century, when the "good roads" movement began, that many of the early turnpike roads were surfaced and became the basic road network in West Virginia until the completion of the Interstate system and other "super" highways. Beginning in the second decade of this century, whole sections of the former Weston and Gauley Bridge Turnpike were taken over to form what is now US Route 19. Nevertheless, there are original sections of turnpike--the Staunton to Parkersburg Turnpike and undoubtedly others--which were not improved and remain in nearly original condition (such a section of the Weston and Gauley Bridge Turnpike is shown in Figure 7).

Getting West Virginia out of the mud was an immense undertaking, since there were virtually no paved roads or adequate bridges outside towns. As late as 1922 there were no paved roads leading out of Morgantown in any direction. This was the rule and not the exception for most towns in West Virginia. Bridges tended to be built before the road was paved.

Beginning in the 1880s, following a virtual hiatus in bridge building for nearly two decades after the Civil War, there was a renewed interest in bridge building. The movement gained strength until the Great Depression, and increasing numbers and varieties were built throughout the state. Because of the topography, an

Figure 7. Original Section of Weston and Gauley Bridge Turnpike

immense number of bridges was necessary, considering the size of the state, its population and the total road mileage. This building activity should, however, be viewed as typical of the efforts other states were making to upgrade their road systems.

The American Covered Bridge

Background

For longer-span bridges over major river crossings, the timber truss covered bridge was developed. The covering served the practical purpose of protecting the main truss members from the weather. Such bridges were used for local roads as well as on turnpikes. In the early days of railroads, covered bridges were also used on railway lines.

Although the origins of the covered bridge can be traced to Europe, it can be said to be a unique American genre which lead to the development of the all-metal truss bridge. The antecedents of the American timber covered bridge may have come from an early craft tradition of building in timber. Roof trusses in timber were popular in the medieval period and the earliest known use was in Roman basilicas. Clearly, the king and queen post trusses used in short-span timber bridges were based on roof trusses dating back many centuries.

The Swiss also built notable timber bridges, which reached spans of over 300 feet. The Schaffhausen Bridge over the Rhine by Ulrich Grubermann (1709-1783) was completed in 1758 and is extant. With its heavy struts carried back to the abutments, it is hardly the forebear of the American truss bridge (see Figure 8). If not providing a prototype as far as the structural system was concerned, it may, nevertheless, have provided the inspiration for building timber covered bridges on a craft basis.

The American timber truss bridge originated in New England in the last two decades of the 18th century. During this period

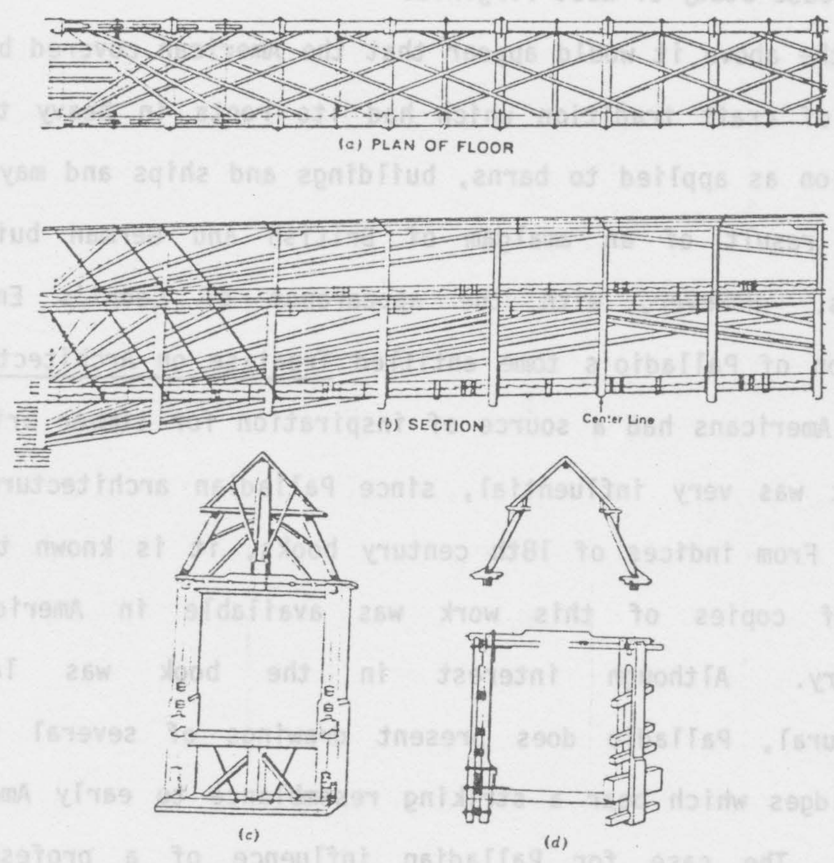

Figure 8. Schaffhausen Bridge, Switzerland - Cooper

bridges were built by Samuel Sewal at Boston in 1785, by William P. Riddle at Manchester, New Hampshire, in 1792 and by Enoch Hale at Bellam Falls, Vermont, in 1792. Hale's Bellow Falls Bridge was apparently a stringer bridge with struts radiating from the piers and abutments. Among the early pioneer bridge builders, Lewis Wernwag and Theodore Burr deserve special attention, since they made major contributions to the art of bridge building and are associated with this case study of West Virginia.

From the above it would appear that the American covered bridge grew out of craft tradition which had its roots in heavy timber construction as applied to barns, buildings and ships and may have been the result of an amalgam of British and German building techniques. However, with the appearance of Leoni's English translation of Palladio's tome entitled <u>Treatise on Architecture</u> [1] in 1742, Americans had a source of inspiration for timber bridges. This work was very influential, since Palladian architecture was popular. From indices of 18th century books, it is known that a number of copies of this work was available in America by mid-century. Although interest in the book was largely architectural, Palladio does present drawings of several timber truss bridges which bear a striking resemblance to early American examples. The case for Palladian influence of a professional literary tradition is further strengthened by Timothy Palmer's work, beginning with the Newburyport Bridge in 1796. Palmer (1751-1821)

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[1] Palladio, Andrea, <u>A Treatise on Architecture</u> (English translation by G. Leoni), London, 1742.

built a number of bridges in New England before moving further afield. His most famous bridge was the great three-span Permanent Bridge across the Schuylkill River at Philadelphia. This bridge was the first known example of an American bridge covered with a roof and siding to protect it from the elements. In addition, the truss work bears a close resemblance to Palladio's drawings. The influence of Palladio thus seems evident in early American bridge work, yet it is not proven, nor can one dismiss the craft tradition of covered bridge building.[2]

Lewis Wernwag and The Colossus

Lewis Wernwag (1769-1843) is important for his work in Virginia and elsewhere, since he represents the craft of bridge building at its finest. Unlike later German immigrants of the 1840s who were trained engineers and scientists, Wernwag came from an earlier millwright tradition. He was born in Riedlingen, Wüttemburg, Germany, and in 1786, at the age of 17, settled in Philadelphia. He was connected with a number of ventures which involved manufacturing or building until 1810. During that year he erected his first timber bridge across Neshaminy Creek. This was later the site of a Finley chain suspension bridge serving traffic on the Philadelphia-to-New York road. After several more bridges, Wernwag's reputation as a bridge builder was firmly established with the construction of the 340-foot span, "Colossus of Fairmont," across the Schuylkill River. (This magnificent structure was burned

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2 Allen, Richard Sanders, Covered Bridges of the Northeast, Stephen Greene Press, Brattleboro, Vermont, 1957, pp. 10-13.

in 1838, providing Charles Ellet, Jr. with the opportunity to build the first long-span suspension bridge in America in 1842.)

For the next dozen years, Wernwag was involved in the construction of numerous bridges and industrial buildings, together with other projects. In 1824 he purchased the Isle of Virginius at Harpers Ferry and there established a manufacturing center. This move to Virginia brought him in contact with the Baltimore and Ohio Railroad, for which he built bridges, the most notable being a Y-shaped bridge over the Potomac at Harpers Ferry. Ironically, one of Wernwag's smallest structures was to become famous as a result of John Brown's raid in 1859--the engine house at Harpers Ferry which sheltered Brown and his men during the abortive raid.

Wernwag, who had difficulty relating to the new breed of engineers being trained at West Point in the science as well as the art of engineering, designed a number of bridges which were built by others, and other bridges have been credited to him without verification. Thus, it is uncertain how many bridge projects he was involved with during his career.

Josiah Kidwell completed a notable two-span covered bridge over the Cheat River in 1837 on the Northwestern Turnpike. It was built according to Wernwag's design and survived until destroyed by fire in the 1960s (the framing system for this bridge is shown in Figure 9). There are no extant Wernwag bridges, and only the fire engine house at Harpers Ferry remains as a monument to this ingenious bridge builder.

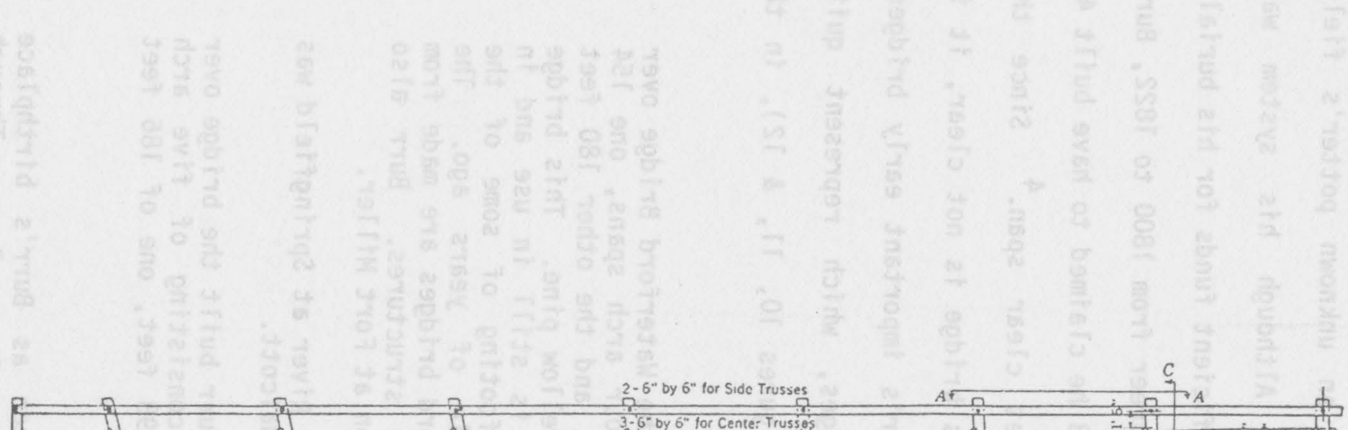

Figure 9. Wernwag's Bridge over the Cheat - Davis and Jemison

Theodore Burr and the Arch Truss Bridge

Theodore Burr was born in Torringford, Connecticut in 1777, and at his death in 1822 was buried in an unknown potter's field somewhere in eastern Pennsylvania.[3] Although his system was widely used, he died in debt, with insufficient funds for his burial.

During his active bridge-building career from 1800 to 1822, Burr built dozens of timber bridges. In 1818 he claimed to have built 45 bridges, ranging from 60 to 367 feet clear span.[4] Since the inspiration for the combined arch truss bridge is not clear, it is instructive to examine several of Burr's important early bridges. Cooper describes three of the bridges, which represent quite different structural solutions (see Figures 10, 11, & 12), in the following way:

> In 1804 Theodore Burr built the Waterford Bridge over the Hudson River, consisting of four arch spans, one 154 feet, one 161 feet, one 176 feet, and the other 180 feet clear spans. The timber is hewn yellow pine. This bridge was not covered until 1814, but is still in use and in reasonably good condition. The footing of some of the arches required renewal a couple of years ago. The drawings of the Easton and Waterford bridges are made from sketches taken from the existing structures. Burr also built another bridge over the Hudson at Fort Miller.
>
> A bridge over the Connecticut River at Springfield was built about this same date by Mr. Walcott.
>
> From 1801 to 1806, Theodore Burr built the bridge over the Delaware River at Trenton, consisting of five arch spans, two of 203 feet, one of 198 feet, one of 186 feet

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3 Many references give Torrington as Burr's birthplace and indicate that he was related to Aaron Burr. Through extensive research, Allen (see previous footnote) has shown that both of these claims are groundless.

4 Allen, Richard Sanders, Covered Bridges of the Middle Atlantic States, Stephen Greene Press, Brattleboro, Vermont, 1959, pp. 8-13.

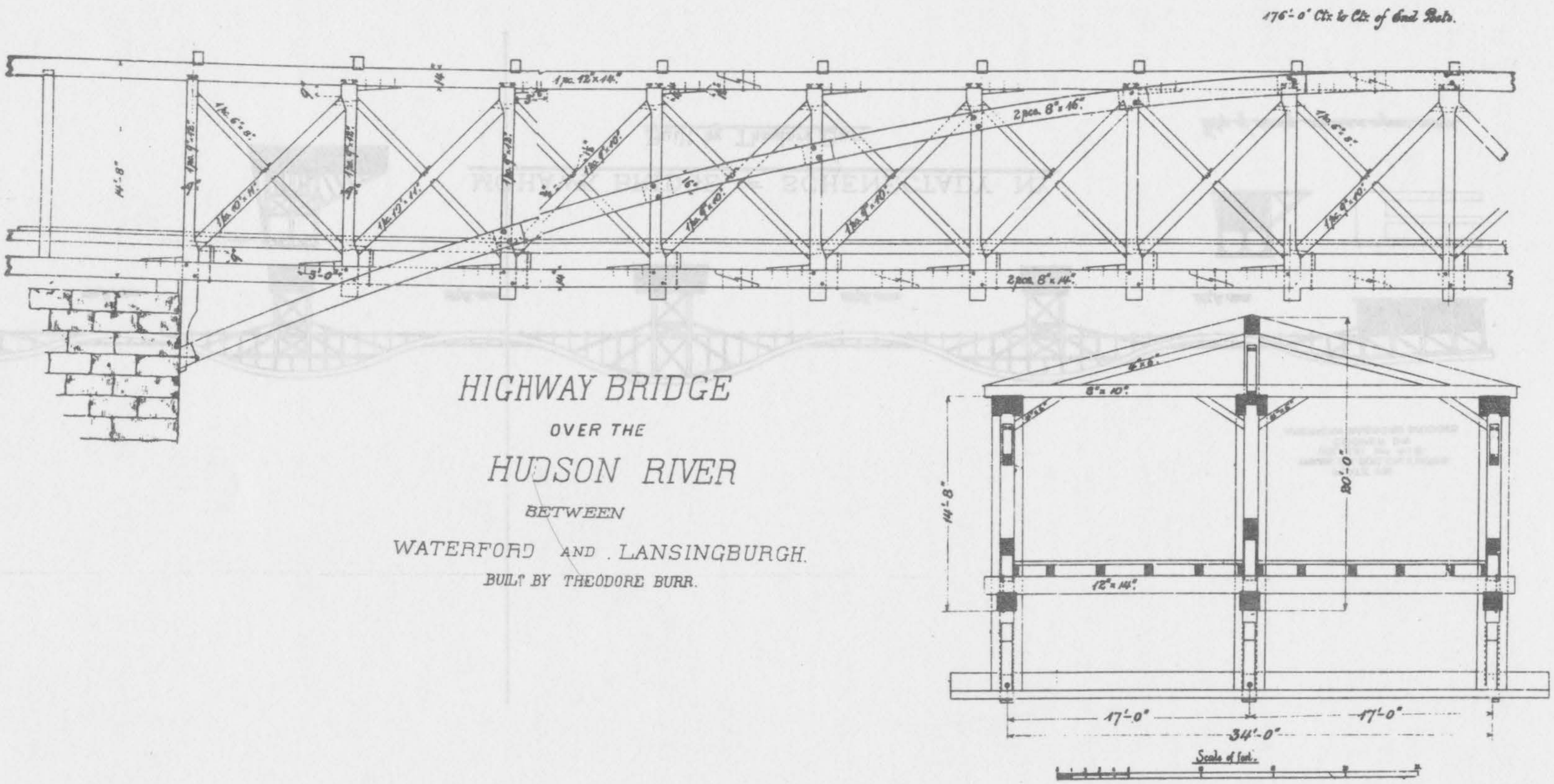

Figure 10. Burr's Waterford Bridge - Smithsonian Collection

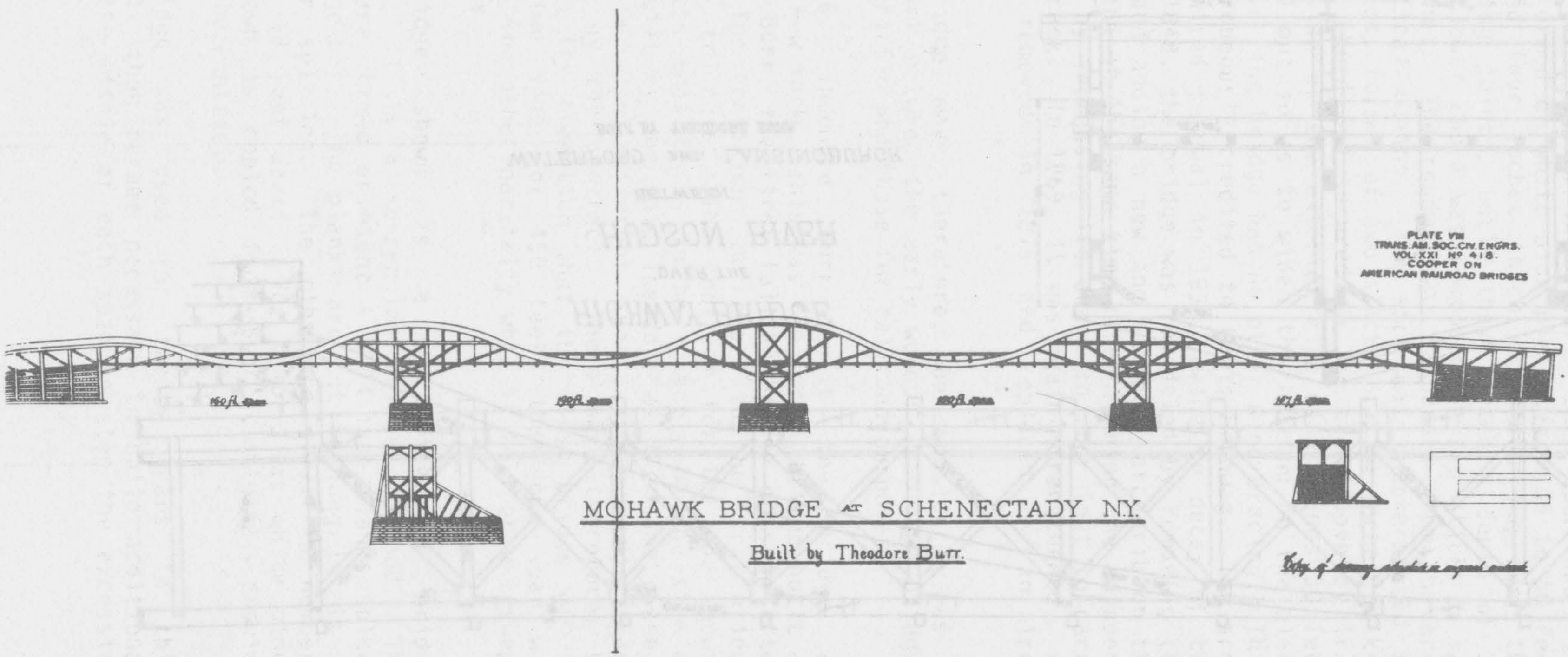

Figure 11. Burr's Mohawk Bridge - Smithsonian Collection

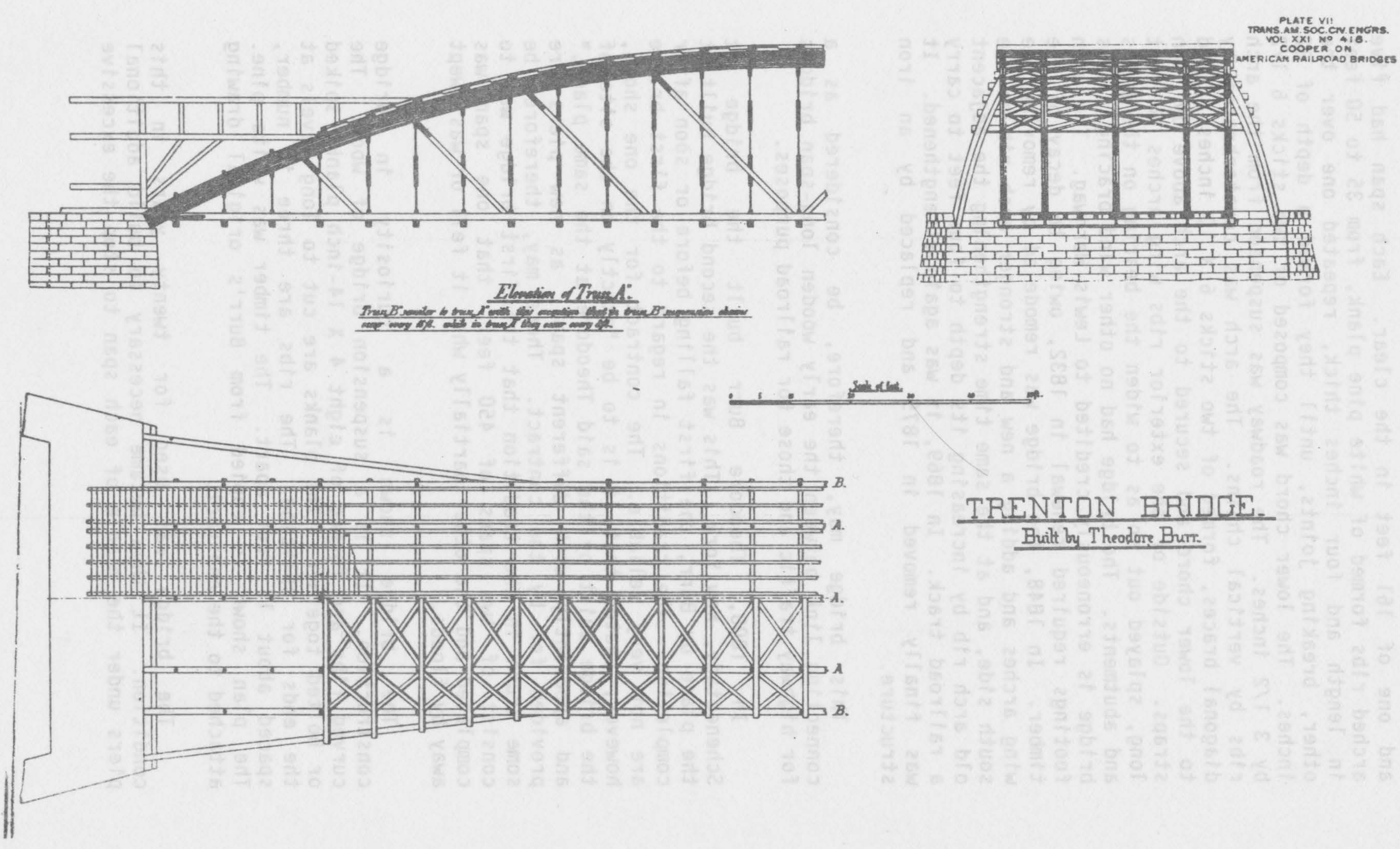

Figure 12. Burr's Trenton Bridge - Smithsonian Collection

and one of 161 feet in the clear. Each span had five arched ribs formed of white pine plank, from 35 to 50 feet in length and four inches thick, repeated one over the other, breaking joints, until they formed a depth of 32 inches. The lower chord was composed of two sticks 6 1/2 by 3 1/2 inches. The roadway was suspended from the arch ribs by vertical chains. The arch was counterbraced by diagonal braces, formed of two sticks 6 X 10 inches spiked to the lower chord and secured to the arch above by iron straps. Outside of the exterior ribs wing arches 50 feet long, splayed out so as to widen the bearing on the piers and abutments. The bridge had no other wind bracing. This bridge is erroneously credited to Lewis Wernwag. The arch footings required renewal in 1832, owing to decay of the timber. In 1848, the bridge was remodeled by removing the wing arches and adding a new and stronger arch rib on the south side, and at the same time strengthening the adjacent old arch rib by increasing its depth to four feet to carry a railroad track. In 1869, it was again strengthened. It was finally removed in 1875 and replaced by an iron structure.

This bridge may, therefore, be considered as a connecting link between the early wooden long-span bridges for highway traffic and those for railroad purposes.

In 1808, Theodore Burr built the bridge at Schenectady, New York. This was the second bridge built at the place by Burr, the first falling before or soon after completion. The traditions in regard to the first bridge are not very reliable. The contract for the one shown, however, states that it is to be "exactly on the site of the bridge built by the said Theodore at the same place," and apparently with different spans, as new piers are provided for by the contract. There may, therefore, be some truth in the tradition that the first bridge was to consist of two spans of 450 feet, that one span was completed and the other partially when it fell or was swept away by floods.

The bridge shown is a curiosity in bridge construction. It is a suspension bridge of wood. The curved ribs are formed of eight 4 X 14-inch planks spiked or bolted together. The planks are cut to long levels at the ends for splicing. The ribs are three in number, spaced about 13 feet apart. The timber was white pine. The plan shown is copied from Burr's original drawing attached to the contract.

The bridge was used for twenty years in this condition. It then became necessary to build additional piers under the middle of each span to stop the excessive

sagging of the bridge. In this condition it stood until 1873, when it was replaced by an iron bridge.

From 1812 to 1816, Theodore Burr built the bridge at Harrisburg, Pennsylvania, over the Susquehanna River, consisting of twelve spans of about 210 feet. The half of this bridge which is south of the Island still remains in use. [5]

Commenting on these bridges and noting that the Susquehanna River Bridge was famed for its great length and called the "Camelback" because of excessive deflections, Fletcher and Snow state:

> These four bridge types seem to have been experimental, in a sense, with Mr. Burr. His patent, dated 1817, which included a drawing of the Waterford Bridge..., ultimately claimed nothing but the arch combined with the truss, the arches springing from the face of the abutment below the bridge seat. Although this bridge was built a year or two earlier, it looks as if it might be a derivation and improvement of Palmer's Easton Bridge. The parellel chords of the trusses made ideal supports for the roof and floor; its posts and other members were firmly connected with arches at each panel point, thereby acting perfectly as stiffeners for the arches. The bridge presents a combination of features, the theoretical value of which was little realized by Mr. Burr. The other types, built with splendid workmanship, did commendable service, except the Mohawk River anomaly, which had to be held up by a trestle after 20 years of use. The Waterford type, under the name of the Burr truss, was used all over the United States as long as purely wooden trusses were built. The type is well adapted for deck bridges, but few prominent instances of such use have come to the notice of the writers. In this type, Mr. Burr really inaugurated the combined arch and truss, which has developed in Twentieth Century steel bridge practice through the spandrel-braced arches at Hell Gate and Kill Van Kull in New York Harbor and at Sydney, New South Wales, Australia. What are they but two-ribbed arches with stiffening trusses built between? [6]

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[5] Cooper, Theodore, "American Railroad Bridges," Paper No. 418, Transactions, Volume XXI, ASCE, July 1889.

[6] Fletcher, Robert and Snow, J.P., " A History of the Development of Wooden Bridges," Transactions, Volume 99, ASCE, 1934, pp. 314-408.

Conceptually, the arch plays the same role in the Burr system as the cables in a suspension bridge with a stiffening truss. Could it be that Theodore Burr shared this conception? His early experimentation with the suspension system on the Schenectady Bridge and the prototype of the Burr system on the Waterford Bridge would tend to support this speculation.

The most important structural characteristic of the Burr arch truss system, compared to a multiple king post truss, is its stiffness and associated deflections. For long-span timber bridges such as the Barrackville Bridge, the arch provides a necessary stiffening of the truss so that deflections resulting from live and dead loads and the effects of creep and shrinkage are controlled to acceptable limits. This additional stiffening is achieved economically, with only a minimum increase in the dead load.

A previous study [7] indicates that the Burr arch truss was conceived as a multiple king post truss with the truss stiffened for long-span application by the addition of an arch. This contention is supported by the early timber bridge builder's rule of thumb: spans in excess of 70 feet should be designed with an arch. In the absence of a method for determining stresses, early bridge builders were nevertheless capable of making observations regarding deflection and developing empirical rules for insuring that the resulting structures did not deflect excessively.

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7 Kemp, E. L. and Hall, John, "Case Study of Burr Truss Covered Bridges," Engineering Issues, Vol. 101, No. E13, ASCE, July 1975, pp. 391-412.

It is likely that the early timber bridge builders were inspired by Palladio, but each developed unique structural systems. In the case of the Burr system, it is the highest development of the "all wood" covered bridge. However, it did not lead directly to the development of the all-iron truss, which is a major American contribution to the art of bridge and building construction. The transition from timber to iron was accomplished by simpler structural systems such as the patented Howe truss, which was easier to prefabricate and did not require the shipwright skills of the Burr system.

Further, it is a tenuous argument to suggest that the Burr arch truss is the forebear of the metal braced arch. Nevertheless, Theodore Burr rightfully deserves credit for having developed a highly successful timber bridge system which found wide acceptance in antebellum America. Writing at the end of the 19th century, William Burr salutes the accomplishments of the leading first-generation timber bridge builders when he says:

> The names of Palmer, Burr and Wernwag were connected with an era of admirable engineering works, but with bridge analysis practically unknown, and the simplest and crudest materials at their disposal, their resources were largely constituted of an intuitive engineering judgment of high quality and remarkable force in the execution of their works never excelled in American engineering. The works they constructed form a series of precedents which have made themselves felt in the entire development of American bridge building. [8]

Lemuel Chenoweth: West Virginia's Pioneer Covered Bridge Builder

After the Northwestern Turnpike (US Route 50) was completed,

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8 Burr, W.H., Ancient and Modern Engineering and the Isthmian Canal, John Wiley and Sons, New York, 1902.

Col. Crozet planned another road across the mountains, the Staunton to Parkersburg Turnpike. Authorized by an act of 1823, which directed the Virginia Board of Public Works to undertake preliminary surveys to establish the route, the road was many years under construction, with building carried on simultaneously in a number of counties. As late as 1860, acts were still being promulgated for reconstruction and repairs. The construction of the turnpike was more a continuous process than a short-term project. In an effort to provide suitable bridges all along the western portion of the roads, the Board of Public Works advertised for bids for the construction of timber bridges.

At this point a little-known wagon-maker and carpenter entered history. Lemuel Chenoweth was born near Beverly, Virginia (now West Virginia) in 1811. Like Abraham Lincoln, he received little formal education, since local schools at the time were supported by funds from state penalties and fines and were at best limited and irregular. However, as a boy he developed a considerable local reputation for his mathematical prowess. He was largely self-taught. Apart from wagons and furniture, Chenoweth had built several small timber bridges in the Weston area. Thus, when time came to bid on the proposed bridges for the center section of the Staunton and Parkersburg Turnpike, Chenoweth decided to try his hand. In his book, Covered Bridges in West Virginia, Calvin R. Conway relates what has become an Appalachian folk legend:

> How Lemuel Chenoweth got the contract to build bridges for the State of West Virginia is one of the famous stories connected with covered bridges in West Virginia. Sources of information vary as to the details, but the main points are well established.

Although records in Richmond credit Lewis Wernwag with having designed the wooden-arch type of covered bridge, a story current in West Virginia relates that Chenoweth, a cabinet-maker by trade and a student of mathematics, arrived in Richmond in 1850 with a model of his bridge packed in his saddle bags. Bidders were present in large numbers from the east and the north to get the bid for the construction which had been highly advertised. Many types of models were presented including iron structures, wire cables, cantilevers, stone arches, and many kinds of wooden bridges. Before the Board of Public Works of the Commonwealth of Virginia, then considering bids for the construction of bridges on the Staunton-Parkersburg Turnpike, Chenoweth assembled his model, "made of poplar, and nary a nail in 'er." Each bidder showed his model and set forth his claims of what weight his bridge would sustain. Mr. Chenoweth was one of the last called forward to show what he had. His plain wooden model didn't attract much attention but he created consternation among the other bidders when he placed his model between two chairs, stood upon it, and challenged the other bidders to put their models to the same test. Not one would do it, for they knew their models would be crushed. That he won the contract through this test has been disputed but he did build many covered bridges in West Virginia between 1851 and his death in 1884.

Just how many bridges were built by Lemuel Chenoweth under the contract with the State of Virginia or during his lifetime is undetermined. There is definite information from good sources that he built the following bridges: Philippi and Middle Fork, Barbour County; Barrackville, Marion County; Beverly, Randolph County; Weston, Stone Coal Creek and Polk Creek, Lewis County; Buckhannon, Upshur County; and the Greenbrier bridge at Marlinton, Pocahontas County. Of the nine named, the first five are still standing, although the one at Beverly was rebuilt by Chenoweth in 1872-73. There is reason to believe that he also built three other bridges in Lewis County. An act was passed by the Virginia legislature in 1847 to build the bridge at Weston and the one across Stone Coal Creek and in 1848 the one across Polk Creek. Under this same act funds were provided for the building of three other bridges: one over the Tygart Valley River at Huttonsville, one over the Hughes River and over Alum Fork. None of the three is still standing, however.[9]

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[9] Conaway, Calvin R., Covered Bridges in West Virginia, West Virginia University, 1947.

Of all Chenoweth's bridges, two of his most important structures--the Philippi and Barrackville covered bridges--are all that remain. Both were constructed using the Burr system.

Built in 1852, the Philippi bridge was used by both Confederate and Federal armies for the transportation of men and supplies during the Civil War (see Figure 13). The first land battle of the war occurred at Philippi on June 3, 1861, when Confederate troops under Colonel Porterfield were routed by Federal troops from General McClellan's army under Colonel Kelly. It was really a minor skirmish, but McClellan made much of it.

The handsome arch truss design is "double barreled" and has two spans, each 138 feet, 8 inches. The superstructure was constructed of clear yellow poplar. The abutments and central piers were constructed by Emmett O'Brien. In 1934 the bridge was overhauled extensively. A reinforced concrete deck supported on steel beams which are, in turn, supported by the original abutments and pier and two new piers has resulted in a bridge within a bridge, since the timber arch truss no longer carries vehicular loads.

The second extant structure is the bridge at Barrackville on the Fairmont and Wheeling Turnpike. This bridge was under construction while Chenoweth was still engaged with other bridges on the Staunton-to-Parkersburg Turnpike. On April 25, 1853 a contract was made between Austin Merrill, the superintendent of the Turnpike appointed by the President and Directors of the Board of Public Works of Virginia, and Lemuel and Eli Chenoweth for the construction of the superstructure by December 1, 1853, if the abutments were

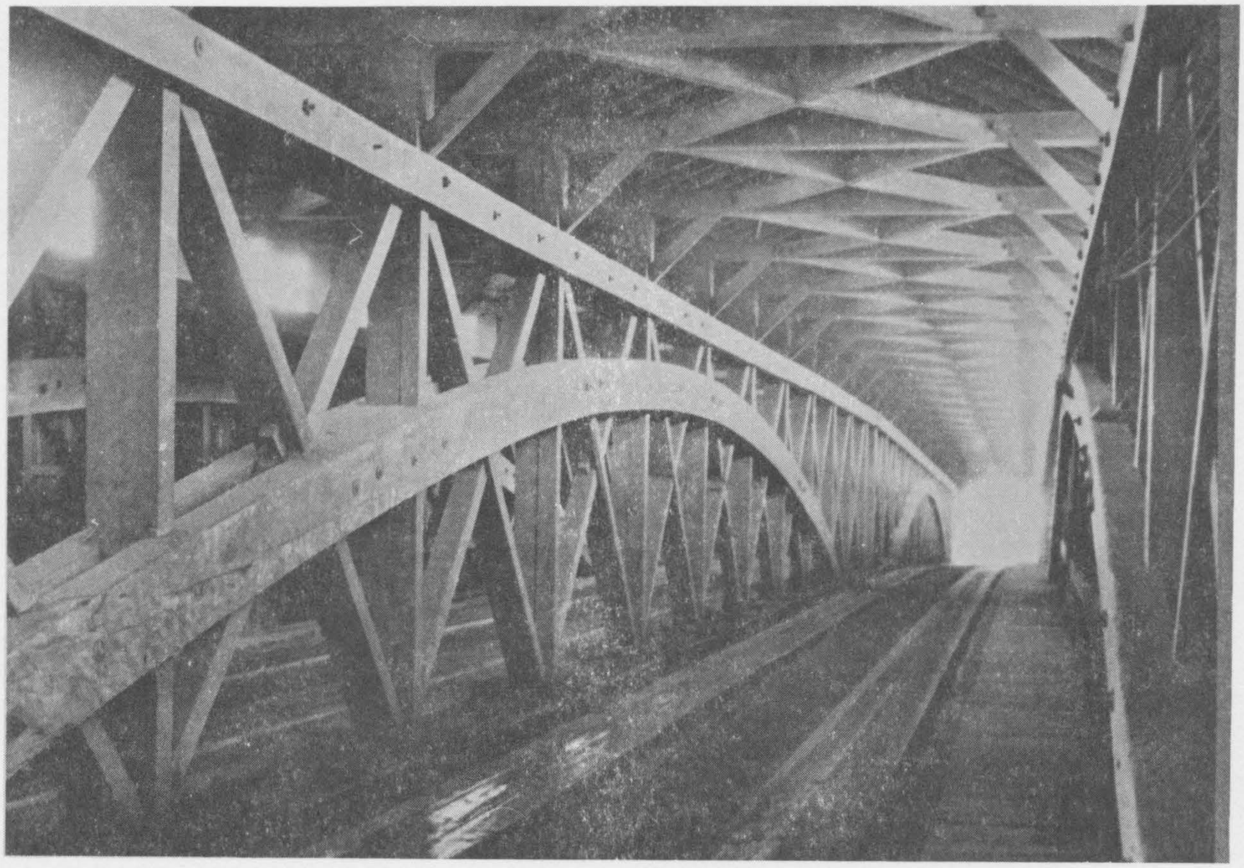

Figure 13. The Philippi Bridge

finished by September. Thus, the builders had only two and one-half months to complete all of the timber work.

The contract provisions for the conduct of employees were of considerable interest in light of today's labor agreements. They says in part,

> If any workman, laborer, or other person employed in the execution of the work herein contracted for shall willingfully insult or maltreat travellers or others passing along, or shall be habitually intemperate, disorderly or unfaithful in this work, the superintendent shall have the right forthwith to dismiss the offender from employment on the said work. [10]

Figures 14, 15 & 16 show the elevation, typical joint detail and interior view of the framing. The bridge is in essentially original condition and is a magnificent example of a Burr arch truss. All of the main timbers were cut out of solid yellow poplar, whereas the treenails (i.e., pegs used in the joints and pronounced "trunnels") are oak. The workmanship throughout is really first-class and worthy of the New England shipwright tradition, which gave birth to the timber bridge in this country.

Upon satisfactory completion of the bridge, the contract states,

> ...the said Austin Merrill superintendent as aforesaid, for and in behalf of the said President and Directors and for and in consideration of the work and labor herein before agreed to be done by and on the part of the said Eli Chinowith (misspelling which occurs throughout the document), agrees and binds the said President and Directors to pay the said Eli and Lemuel Chenoweth the sum of twelve dollars and fifty cents per foot lineal measure in the manner following viz. Whenever the said Chinowiths shall have done to the amount of five hundred dollars worth of labor on said bridge, they shall be entitled to a draft

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10 Salmon, op. cit. See Items 248 and 563 for Barrackville Bridge, which was part of the Fairmont and Wheeling Turnpike.

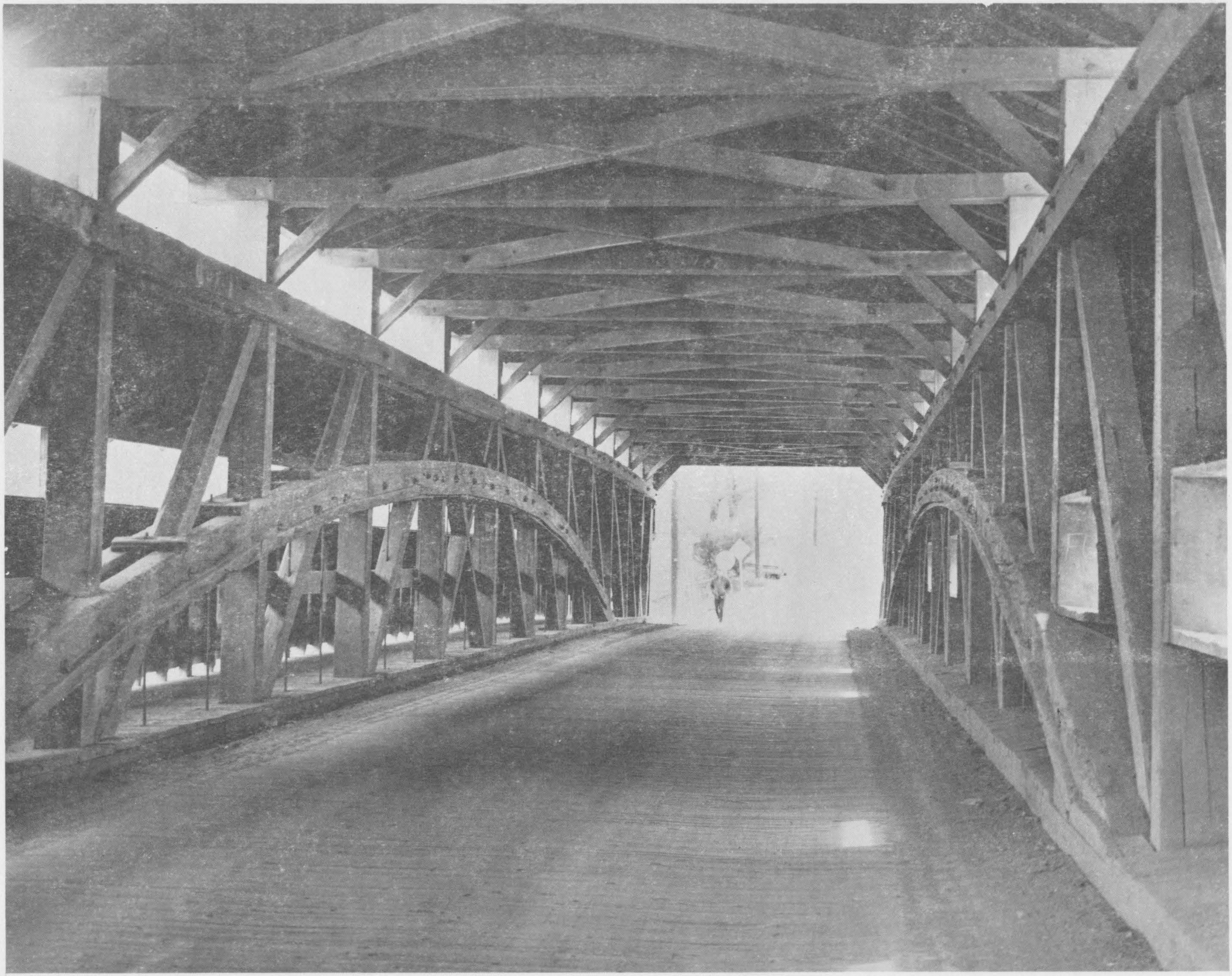

Figure 14. Barrackville Bridge, Interior - William E. Barrett

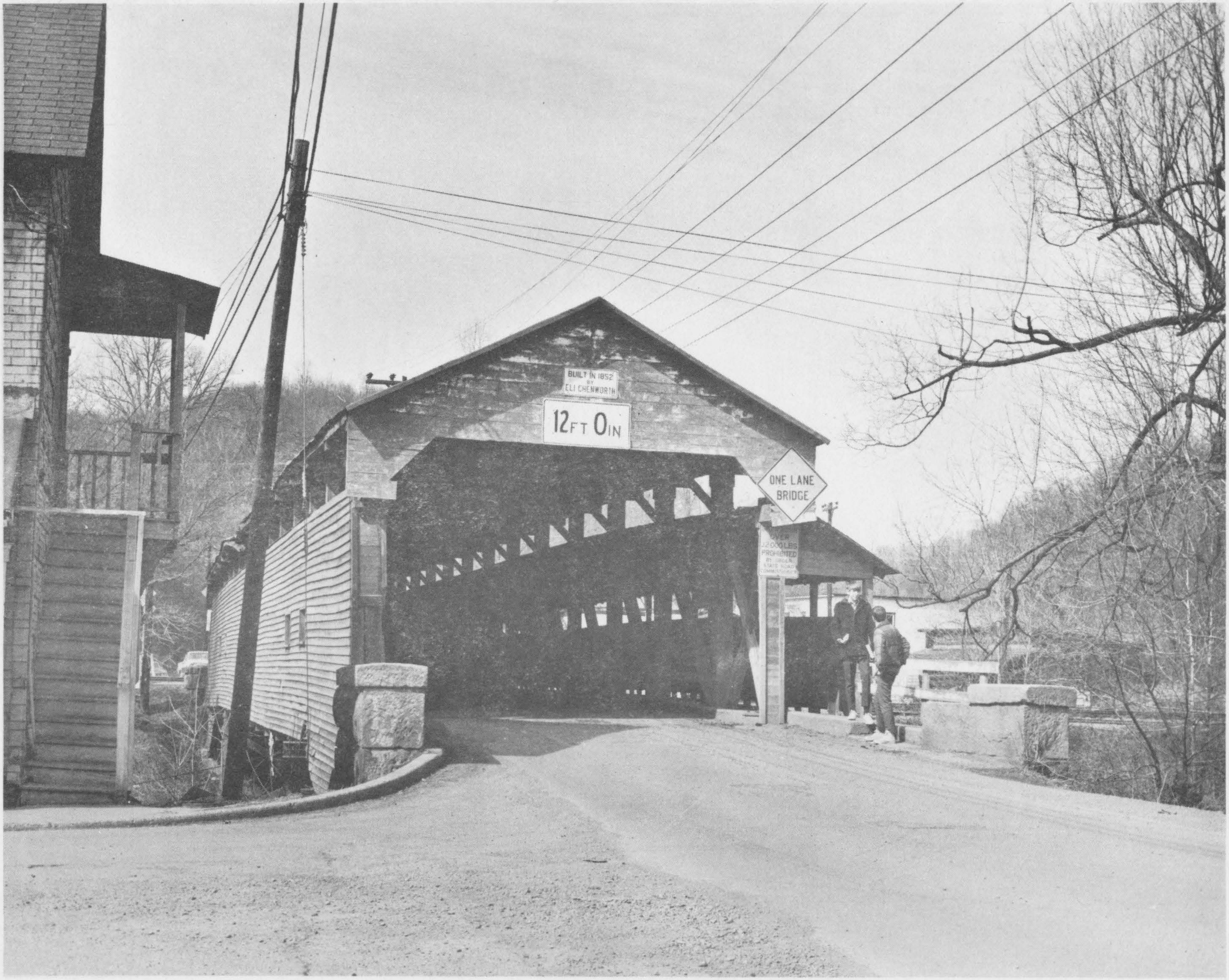

Figure 15. Barrackville Bridge, end elevation - William E. Barrett

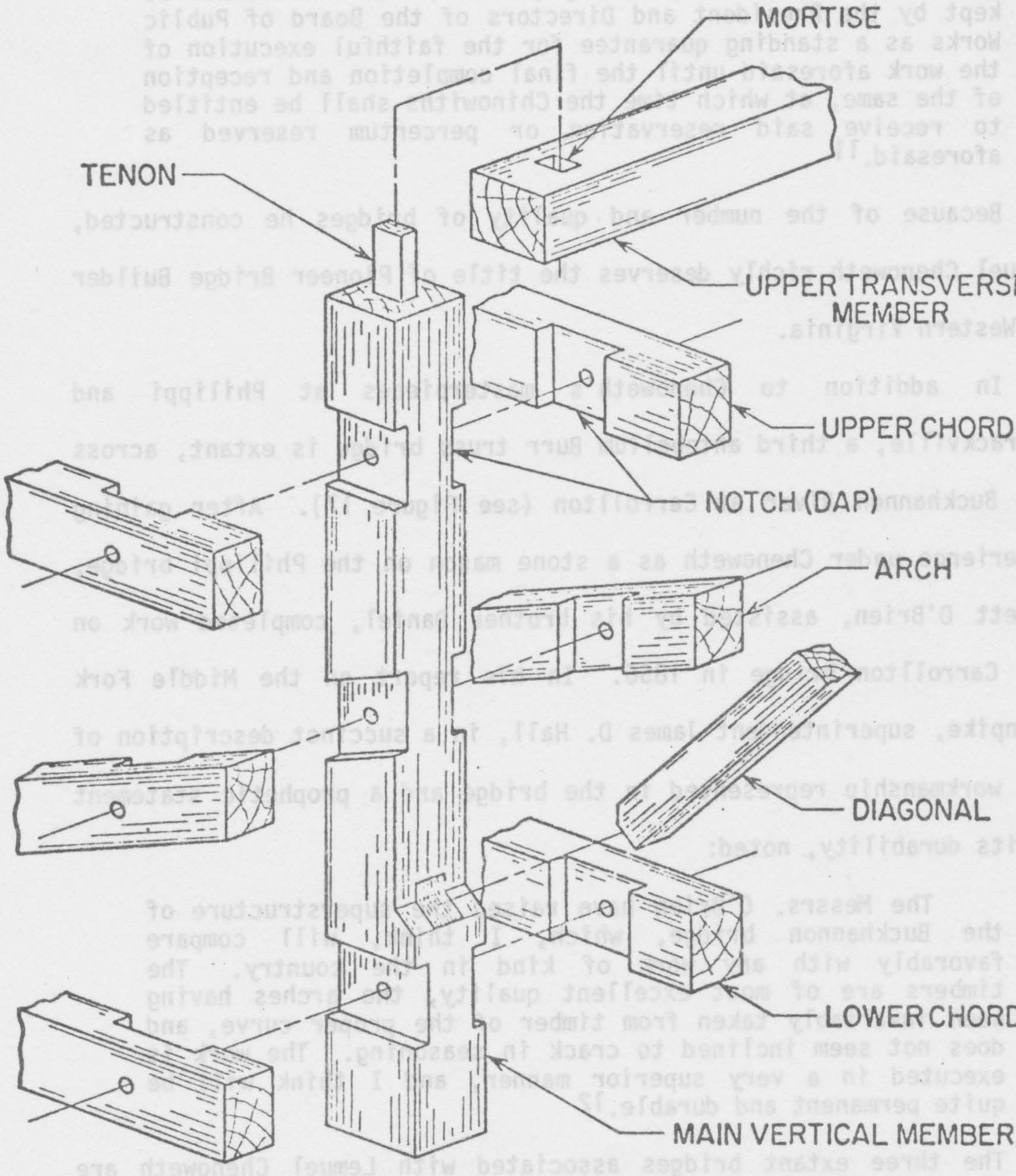

Figure 16. Barrackville Bridge, detail of joint

on the board of Public Works for four hundred dollars, the said reservation of twenty five centum (the hundred-dollar reservation is actually twenty percent) which sum shall be kept by the President and Directors of the Board of Public Works as a standing quarantee for the faithful execution of the work aforesaid until the final completion and reception of the same, at which time the Chinowiths shall be entitled to receive said reservation or percentum reserved as aforesaid.[11]

Because of the number and quality of bridges he constructed, Lemuel Chenoweth richly deserves the title of Pioneer Bridge Builder of Western Virginia.

In addition to Chenoweth's masterpieces at Philippi and Barrackville, a third antebellum Burr truss bridge is extant, across the Buckhannon River at Carrollton (see Figure 17). After gaining experience under Chenoweth as a stone mason on the Philippi bridge, Emmett O'Brien, assisted by his brother Daniel, completed work on the Carrollton bridge in 1856. In his report on the Middle Fork Turnpike, superintendent James D. Hall, in a succinct description of the workmanship represented in the bridge and a prophetic statement of its durability, noted:

> The Messrs. O'Brien have raised the superstructure of the Buckhannon bridge, which, I think, will compare favorably with any work of kind in the country. The timbers are of most excellent quality, the arches having been invariably taken from timber of the proper curve, and does not seem inclined to crack in seasoning. The work is executed in a very superior manner, and I think will be quite permanent and durable.[12]

The three extant bridges associated with Lemuel Chenoweth are historically significant, on a national basis, as outstanding

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11 Ibid. See item 248 and 563.

12 Ibid. See Item 326.

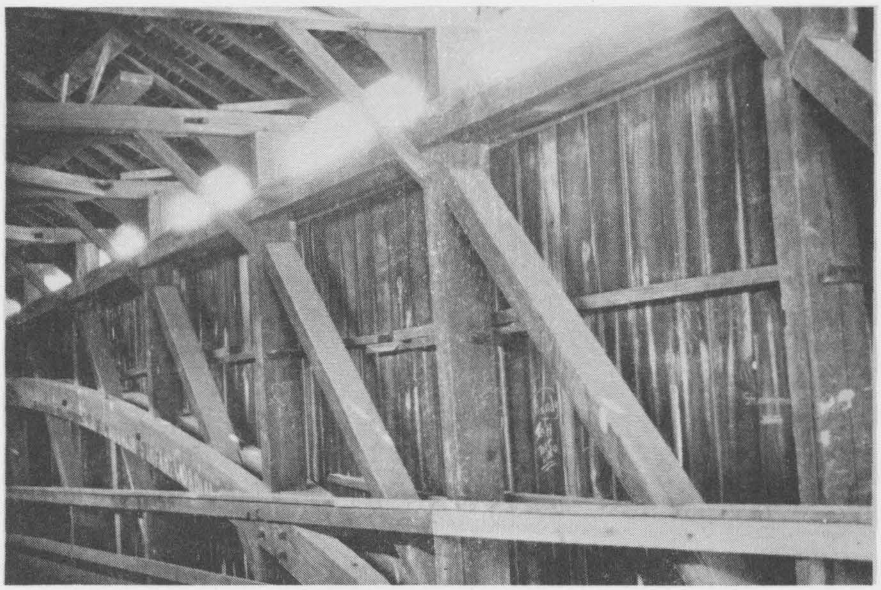

Figure 17. Carrollton Bridge

representations of the scores of bridges built as part of the turnpike movement in America, which flourished before the Civil War. They are also outstanding examples of the classic Burr truss bridge.

Stephen Harriman Long

When Col. Stephen Long (1784-1864) patented his famous wooden truss system in 1830, it marked the beginning of a new era in bridge-building in the United States. In a larger sense, Long was a pioneer in transforming building from an art practiced by craftsmen into a professional activity firmly guided by trained civil engineers.

Long was a man of wide interests who succeeded in making substantial contributions to nearly all the recognized fields of civil engineering. Benjamin Henry Latrobe, Jr. credits him with being the leading engineer of his day in the United States.[13] Although neglected by historians of 19th century America, Long was the epitome of a field marshall of the Industrial Revolution in America. In England such a man would surely have been considered an eminent Victorian.

Born in Hopkinton, New Hampshire, in 1784, Long graduated from Dartmouth College in 1809 and received an A.M. in 1812. After a brief spell teaching school, he served as an assistant professor of mathematics at West Point from 1814 to 1816. Upon joining the U.S.

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[13] This is high praise indeed from Latrobe (1806-1878), son of the famous architect, who rose to fame himself as chief engineer of the Baltimore and Ohio Railroad during its heyday before the Civil War.

Military Academy at West Point he was commissioned a second lieutenant and served in the Army Engineers until his death in 1864. Leaving the Academy in 1816, he was engaged in a series of expeditions in the west. In 1827, with the rank of Brevet Lt. Col., he was assigned to the Baltimore and Ohio Railroad to assist in selecting the route from Baltimore westward toward Wheeling.

It was through such assignments to essentially civilian positions that the academically trained military engineers infused a new sense of professionalism and technical expertise into the national concern for internal improvement. Other engineers were assigned to work on canals, river improvements, mapping and such large-scale undertakings as the National Road from Cumberland to Wheeling.

While working with the Baltimore and Ohio Railroad, Long built his first bridge, the Jackson Bridge near Baltimore, which carried the Washington Pike over the B & O. Before this bridge, the B & O was committed to monumental masonry structures, following traditional British and European practice. Long's bridge ushered in the use of timber trusses for railway use. An extended debate ensued comparing stone masonry and timber bridges. Outwardly it appeared to be simply an issue of expensive permanent stone arch bridges versus what was viewed as a cheap expedient of limited life expectancy. There were, however, deeper and more important issues at stake, involving traditional bridge-building methods and new structural forms based, in part, on the application of structural theory to design. Lewis Wernwag, the German master bridge-builder,

established his career on timber bridges, yet sided with those favoring masonry bridges. His position and the essence of the debate is clearly stated in Wernwag's letter to P.E. Thomas, president of the B & O:

> P.E. Thomas, Esqr.
> Prest. (Baltimore & Ohio) Rail Road
> Baltimore
>
> Harpers Ferry, Dec. 29th, 1829
>
> Esteemed Friend,
>
> I owe to you these few lines to apologize why I did not go out with (you) on the rail road. After I left you I saw Mr. (Col. Stephen) Long and (he and I) had some serious discourse, although in good humour, on bridge building and on stone rails. After I left him my mind was impressed that I should not go out with you and, as I have generally followed a silent inward impression, that is sincerely the truth why I did not go. The cause I cannot account for and as you showed such a friendly disposition toward me, it has awakened such a sympathising feeling toward you, it is the cause of this private letter to you. You said that you wished you had my skills & experience united with your concern on the road. I must sincerely declare I believe it would, but I am determined not to deceive you and you must forgive me if I write to you the truth of my feelings. A man of my age that (has) carried on extensive business for thirty-five years, and all of the knowledge & experience that I am at this time in posession of, I have not got from theory, but from severe knocks on my knuckles. I have handled all those tools for many years, from a crow bar to a moulding plane, to be at the eleventh hour of my days under the control of engineers, as they are called. I would make myself an unhappy being. I would be useless and in fact an injury. With a man of experience of correct feelings like C.M. Weaver (Casper Weaver, B & O supt. of construction), I could do business all my life time and be useful to each other. My dear friend, remember I do not find fault, but I sincerely declare to you what your engineers know as it regards experience. I have forgot they are before me in calculating. They may do it quicker to know how many cubic yeards it would take out of a hill to fill a hole but not in anything else. I close as I said before this private communication. Before you determine on the superstructure of the Monocacy (River Bridge, built by Wernwag), get some gentlemen of sound judgement to examine particularly and distinctly the principles of Col. Long and

my mode of bridge building. Col. Long has always been very friendly towards me. I do not want his ill will, but I know if he puts up as many bridges as I have and standing as long as I have without any expense, then I will shake hands with him on even ground and not before. As soon as I get to Port Deposit (Md.), which will be in three or four weeks, I will make an experiment and let you know what stone rails could be delivered to Balto (Baltimore) per yard. In the mean time I remain.

Your sincere friend

/s/Lewis Wernwag 14

The Jackson Bridge was completed in 1829 and the following year Long published Description of the Jackson Bridge, Together With Directions to Builders of Wooden or Frame Bridges. The Jackson Bridge incorporated all the elements of the well-known Long truss, which was patented in 1830 (see Figure 18). Subsequent patents in 1836 and 1839 perfected the basic patent (details of the Long truss taken from the patent of 1839 can be seen in Figure 19). In his monumental paper of 1889, Cooper says:

> The next step toward simplicity and concentration of parts appears to have been the truss known as the Long truss, patented by Brevet Lieutenant Colonel Long of the United States Engineers, in March 1830 and November 1839.
>
> This also was a form of truss in which iron did not enter as a necessary part, the connections being made by framing the parts together, or by use of wooden keys or treenails. Many bridges were built of this form, but it never became widely popular.
>
> Both the Lattice and Long bridges were combined with the arch in many cases, especially for the longer spans.15

---

14 Long, Stephen H., Description of the Jackson Bridge, Baltimore, 1830.

15 Cooper, op. cit.

Figure 18. Typical Long Truss

LONG'S BRIDGE.

Figure 19. Long's Patented Bridge

It certainly was a simpler system than the popular Burr truss, but its historical significance rests on the fact that it was the first wooden truss system based upon an understanding of structural theory. The essential feature which distinguished it from a traditional multiple king post truss was the provision of counter braces, which served to stiffen the bridge against deflection and in effect prestressed the bridge. This prestressing prevented the joints from working in tension with passage of moving loads and ensured that the members which might change stress during the changing loads remained in compression. In his influential book of 1851, Haupt describes Long's counter braces in the following terms:

> The consideration of the action of counter-braces leads to some very singular but important results.
>
> Let the truss be loaded with a weight so as to produce some deflection, it has been shown that the diagonals in the direction of the braces will be compressed, and in the direction of the counter-braces extended. Suppose that the extension of the last named diagonals is sufficient to leave an appreciable interval between the end of the counter-brace and the joint against which it abuts, and that into this interval a key, or wedge of hard wood or iron, is tightly introduced: it is evident, that upon the removal of the weight, the truss, by virtue of its elasticity, would tend to regain it original position; but this it cannot do, in consequence of the wedges at the ends of the counter-braces, which prevent the dotted diagonals from recovering their original length, and the truss is therefore forcibly held in the position in which the weight left it; the reaction of the counter-braces producing the same effect that was produced by the weight, and continuing the same strain upon the ties and braces.
>
> The singular consequence necessarily results from this, that the passage of a load produces no additional strain upon any of the timbers, but actually leaves some of them without any strain at all.[16]

---

[16] Haupt, Herman, General Theory of Bridge Construction, D. Appleton & Co., New York, 1890, pp. 82-106.

During the 1830s the Long truss was one of the most popular of the patented truss systems and was widely employed for both road and rail bridges. The Long truss bridge was heavily promoted by agents utilizing papers and pamphlets and wood models prepared by Long for the uninitiated in matters of bridge-building.

Long truss bridges were not popular in West Virginia, but at least four were framed according to the patented Long system, of which three are extant. The Staats Mill bridge is particularly significant, since it is accurate in every detail of the patented truss, despite its late date, 1887. In Figure 20, the bridge is shown in its original location at Staats Mill. During the summer of 1982 the bridge was moved to Cedar Lakes and restored to its original condition. The bridges at Sandyville in Jackson County and at Center Point in Doddridge County are both Long trusses, built in 1890 and 1887, respectively.

Wood and Iron: The Howe and Pratt Trusses

William Howe (1803-1852), an inventor and uncle of Elias Howe of sewing machine fame, was commissioned by the Boston and Albany Railroad in 1838 to build a timber railway bridge to a new design. Patented in 1840, this new truss represents the beginning of the transition from timber to iron for both railway and highway bridges. Although the truss resembled Long's earlier patented truss, it was distinguished by replacing the timber tension verticals with wrought iron rods threaded on each end. The joints could be made of cast iron, which greatly simplified the millwright skills needed. Not only was the truss easy to erect, but it could be adjusted and members replaced while in service (see Figure 21).

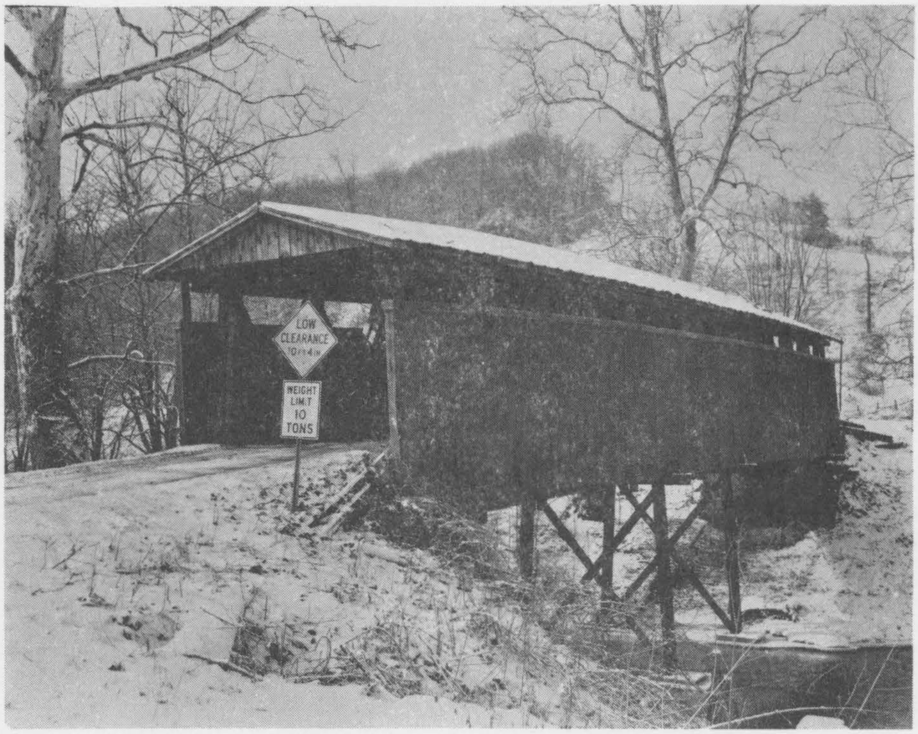

Figure 20. Staats Mill Bridge, 1887

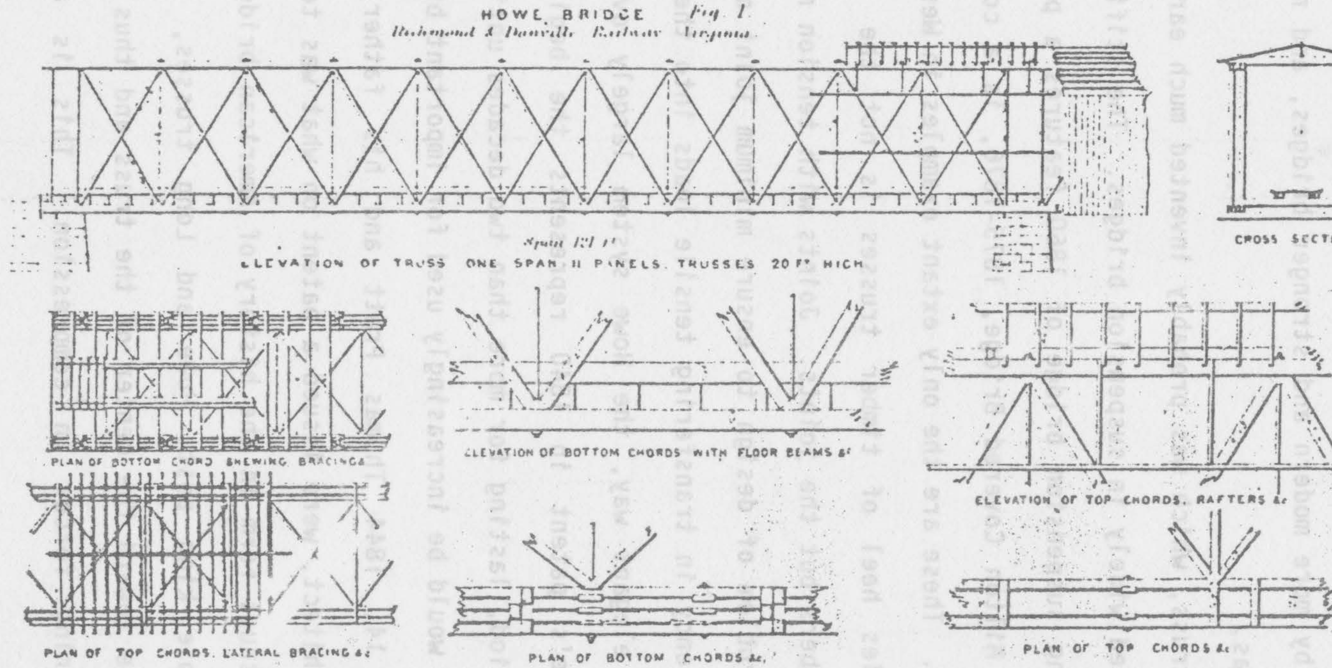

Figure 21. Howe Truss - Cooper

The Howe truss became the most popular bridge for railway use in America until the advent of the all-iron bridge in the 1850s.[17] All-timber railway bridges, except for trestles, have long since been replaced by more modern and stronger bridges, and none remains in the Virginias.

The Howe truss, which was probably invented much earlier by the French, was used widely in suspension bridges. The stiffening truss on the Wheeling suspension bridge of 1860 features a pair of Howe trusses. The Milton Covered Bridge, 1875-1876, is a combined arch and Howe truss. These are the only extant examples in West Virginia.

The Achilles heel of timber trusses is not the strength of individual members but the joints. Joints with tension members pose a difficult problem of design to ensure minimum joint movement and maximum efficiency in transfering tensile loads into the joint. In a simple and elegant way, the Howe system largely overcame this problem. Howe's patent in 1840 represents the beginning of a transition period, lasting for more than two decades until the Civil War, when iron would be increasingly used for important bridges.

On April 14, 1844 Thomas Pratt and his father, Caleb, a well-known architect, were issued a patent on what was to become the most popular truss form in the history of American bridge-building. In the multiple king post, Howe and Long trusses, the primary diagonals slope toward the center of the truss and thus support the vertical shearing forces in compression. This is a sensible

---

17 Since the Howe truss was used largely by railways, none has survived, because increasing locomotive weights necessitated early replacement.

arrangement in timber, since timber members act efficiently in compression and make relatively simple the joints with the verticals at the levels of the top and bottom chords (see Figure 22). In all these trusses, the verticals are in tension. Thus, the genius of the Howe system is that the timber verticals, which pose the most difficult problem in designing an effective joint, are neatly replaced with an iron rod.

The Pratts used an alternative approach by reversing the direction of the diagonals, which placed the verticals in compression and the diagonals in tension. This configuration was not particularly suitable for timber bridges, since the joints were not as simple and elegant as those of the Howe truss. In the case of all-iron trusses, however, the Pratt had several striking advantages which resulted in its lasting popularity.

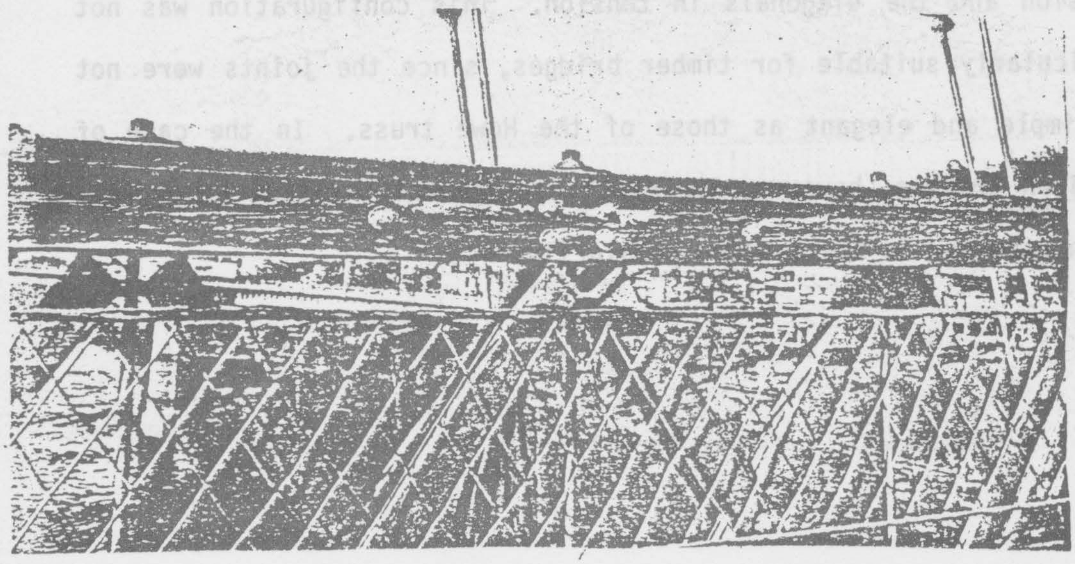

Figure 22. Detail of Howe Truss Joint - William E. Barrett

From Wood to Iron: A Period of Transition (1828-1870)

Visible in the final version of the Howe/Stone truss is a move toward simplification of structural configuration and joint details, made possible by the use of wrought iron tension members and, at least in the East, cast iron joint fittings. From its introduction, the Howe truss became the timber truss most favored by American railways. It was built literally from coast to coast.

The Howe system was used in a number of noteworthy bridges (see Figure 23), but it was not particularly popular for highway bridges. In addition, as will be noted later, the Baltimore and Ohio Railroad developed a unique system of bridges for use in its Main Stem and elsewhere. Thus the Howe truss was never popular in the Virginias except for stiffening trusses of suspension bridges. The sole survivor of this type of truss bridge is the Milton Covered Bridge of 1875-76, which features an arch as well as a conventional Howe truss.

As noted, the Pratt patent called for reversing the direction of the main diagonals, which resulted in the diagonals resisting loads by tension and calling on the verticals to act as compression struts. This was not a particularly advantageous arrangement for an all-timber truss, but was especially suitable for iron, since the tension diagonals could be quite small rods or bars and since the verticals, being shorter than the diagonals, could better resist critical buckling loads for a given cross-section. Although the patent drawings show a truss with both main and counter diagonals,

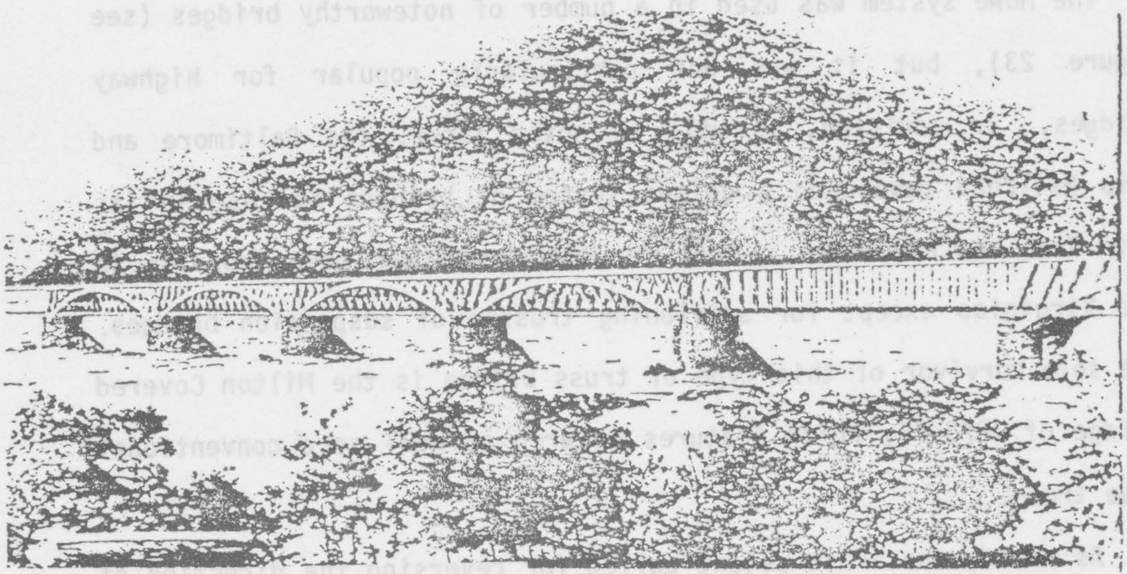

Figure 23. Howe Truss Railway Bridge

the basic type was often further simplified by omitting the counters (see Figure 24). Many bridges of this type are found across the length and breadth of West Virginia.

After consideration of the Howe and Pratt trusses of the 1840s, it appears that a simple transformation occurred in which iron gradually replaced timber in truss bridges. There is merit in this approach, but it obscures a long tradition of using iron in bridges in America, Europe and especially Great Britain. Even more important from the historian's point of view, such an approach does not really reveal the cause of the rapid transition from timber to iron in the 1840s and 50s.

It was the advent of the railway which demanded longer and stronger bridges--longer because of much more severe grade restrictions on a railway than those of a road and stronger because the weight of locomotives was much higher than any traffic loads on the roads. Not only were locomotives initially larger than road vehicles, but they increased in weight at an astonishing rate, from less than 10 tons initially with the diminutive grasshoppers of 1836 to Ross Winan's famous camels of the 1870s which weighed 129,100 pounds. This meant that bridges of greater and greater strength were needed to carry locomotives, which, by the turn of the century, had increased in weight to more than 100 tons. Thus the railways were the leading technology of their day, not only in mechanical engineering but also in the development of structural engineering.

This transition was not merely a change from a traditional to a newly developed material possessing superior structural properties,

of the Erie Canal, Circa 1840-50.

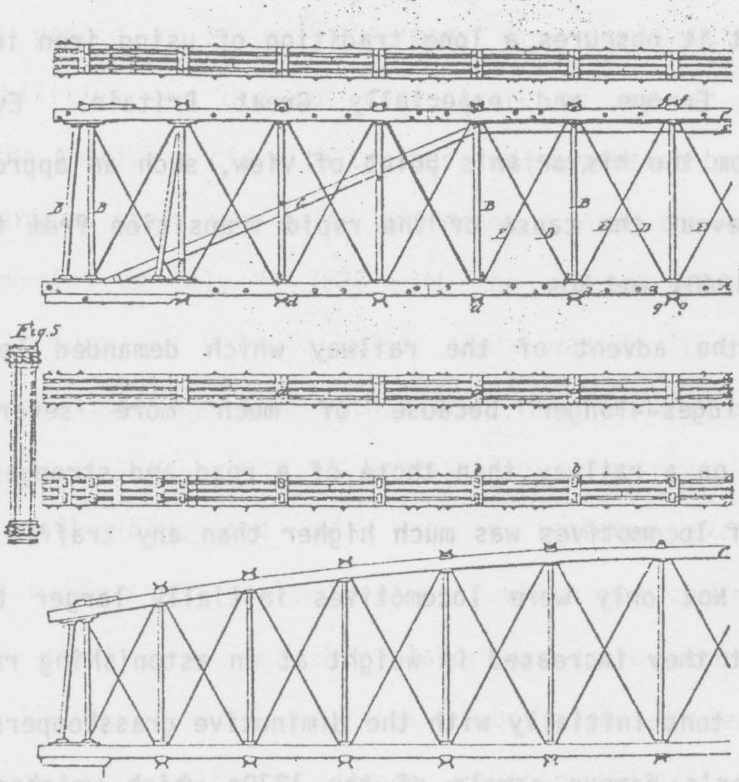

FIGURE 35. Patent Drawing. Thomas W. and Caleb Pratt.
Patent No. 3523.

Figure 24. Basic Pratt Truss

but was also a transition in bridge-building from a craft tradition to the kind of engineering practice known today. This implies structural analysis, the preparation of contract drawings and specifications and, perhaps most important, the development of adequate testing procedures to ensure that the materials used are of an approved quality. The key to this development was the use of iron in structures. The transition period was marred by a number of bridge disasters which forced engineers to consider safety in their designs and the use of quality-controlled iron.

The completion of the iron bridge across the Severn in Shropshire, England, in 1799 represents the beginning of the use of iron for bridges and buildings. However, it also represents the culmination of a long line of development in the production of iron, which made its use feasible for the first time as a structural material. Thomas Paine made a little-known but significant contribution to iron bridge-building, since he was responsible for inspiring the use of iron in long-span bridges, most notably the Sunderland Bridge across the Wear in 1796.[1]

From that point until the middle of the 19th century the British were leaders in the use of cast and wrought iron in bridges, aqueducts and buildings. Thus, by the beginning of the railway age, which was ushered in with the opening of the Liverpool and Manchester Railway in 1826, British engineers had considerable

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[1] Kemp, E.L., "Thomas Paine and His Pontifical Matters," Transactions, Volume 49, Newcomen Society, 1977-78.

experience in building in iron as well as in masonry structures of both brick and stone. With the demands of railways for long-span bridges and viaducts, the British were capable of building in iron a variety of bridge types such as plate girders, arches, trusses and combinations of these types using both cast and wrought iron. For the historian of British engineering, this is indeed a rich and challenging period to study.[2] In many ways the British had too many possibilities and did not concentrate on one or two bridge types, as the Americans did with trusses and suspension bridges.

The American story was quite different. When the railway age began in America on July 4, 1828 with the groundbreaking ceremony for the Baltimore and Ohio Railroad, there was limited experience with brick or stone and none with iron. The first cast iron arch bridge--on the National Road at Brownsville, Pennsylvania--was not completed until 1839, and this was an isolated example. The majority of bridges was built in timber, which was cheap, abundant and easy to erect in a land where labor was scarce and expensive. Thus, the American experience with timber trusses lead to the all-iron truss in a much more direct way than did British practice at the time. It must be remembered that, although iron bar and wire suspension bridges had been built earlier by Finley and in the 1840s by Ellet, Roebling and others, it was not until 1854 that the first structural iron "I" beam was rolled in America by the Trenton Iron

---

2 James, John G., "The Evolution of Iron Truss Bridges to 1850," Transactions, Volume 49, Newcomen Society, 1977-78.

Company. The iron industry's capability for casting large structural members was also quite limited. The truss and wire suspension bridge gave American engineers a structural form in which small iron members or wires could be used to construct large bridges quickly and cheaply.

Technological innovations are not inexorably linked to demand. Simplifying the subject to a single historiographic perspective eliminates the rich human aspect of technological development in the process. Nevertheless, the demand for new bridges of unprecedented size and number was a powerful encouragement for engineers and inventors to turn their attention to new structural forms using iron.

Squire Whipple, et al.

Squire Whipple (1804-1888) had a profound influence on American bridge engineers which was to last beyond his early contributions of the 1840s. Whipple's contribution was twofold: he published the first book on truss analysis available to American engineers and he patented and built one of the first all-iron truss bridges in the United States.

A crude suspension truss was patented by Canfield in 1833 (see Figure 25). It was not particularly well-conceived, efficient or successful, but it was a beginning. This was followed by Delafield's cast iron arch bridge on the National Road at Brownsville, Pennsylvania, in 1839. By 1841 Trumbull had patented an iron bridge composed of X-braced panels together with a suspension chain. As late as 1858 Truesdell erected a composite cast and wrought iron bridge consisting of diagonal and vertical

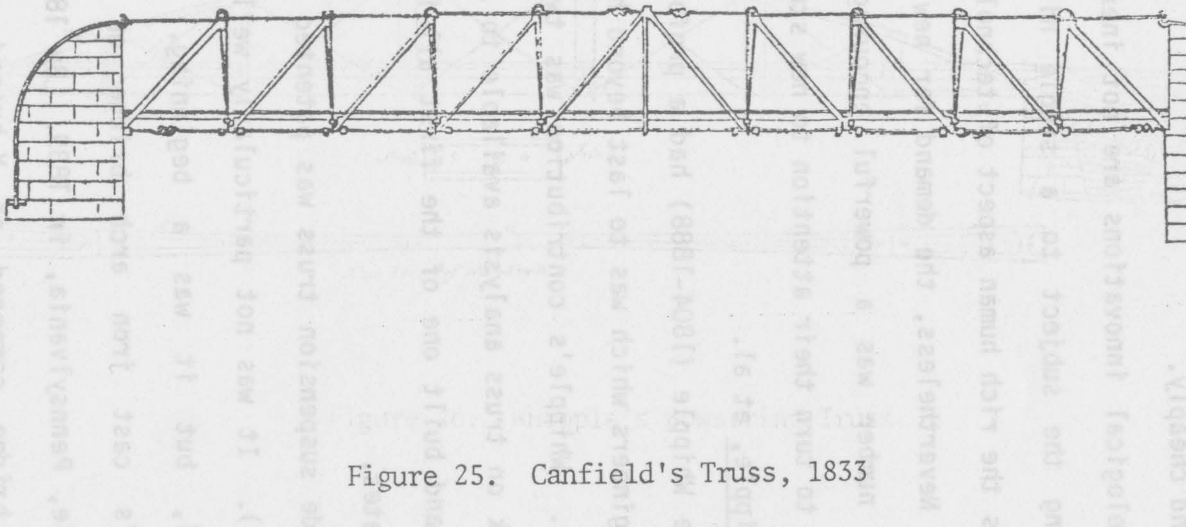


Figure 25. Canfield's Truss, 1833

trusses and a series of longitudinal members connected in a manner reminiscent of Paine's early work more than a half-century earlier. These inventions were merely exploratory and did not result in significant advances in the art of bridge-building.

Born in 1804 and a graduate of Union College, Whipple apparently became interested in bridge-building in the early 1830s as a result of serving as a surveyor on the Baltimore and Ohio Railroad. His inventiveness included work on surveying and canal locks. To many, Whipple's name is associated with the parallel-chord double-intersection Pratt-type truss, but his first patent was for an elegant bowstring truss (see Figure 26), composed of a segmented cast iron arch and wrought iron tension members. Several of these bridges survive in New York State, with a sole survivor in Virginia. None was known to have been built in what is now West Virginia.

In the mid-1840s Whipple developed a double-intersection Pratt-type truss (see Figure 27) and obtained a patent for it in 1847. In 1863 J.W. Murphy modified this design by providing double-intersection counters, resulting in the Whipple/Murphy truss, which was popular for what was then considered to be long-span bridges for both railways and highways. A number of these trusses was built in the western counties of West Virginia bordering the Ohio River and several, dating from the 1880s, survive.

The British engineers, Warren and Monzani, invented a new truss type without verticals (see Figure 28) which was to become very popular for pony truss highway bridges as well as notable railway

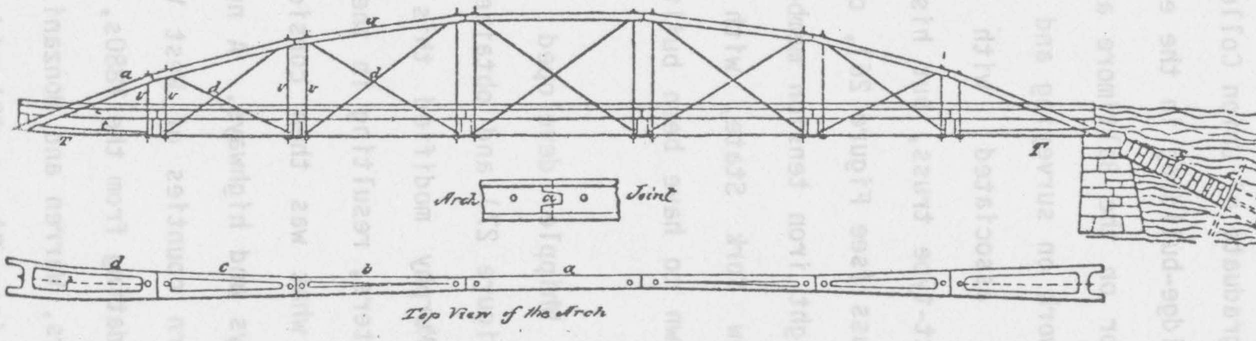
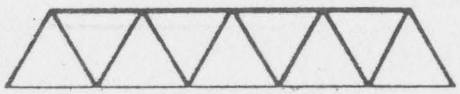


Figure 26. Whipple's Bowstring Truss

Figure 27. Whipple (Double Intersection Pratt)



WARREN

1848 - 20TH CENTURY

TRIANGULAR IN OUTLINE, THE DIAGONALS CARRY BOTH COMPRESSIVE AND TENSILE FORCES. A "TRUE" WARREN TRUSS HAS EQUILATERAL TRIANGLES.

LENGTH: 50-400 FEET
15-120 METERS

WARREN

WITH VERTICALS
MID 19TH-20TH CENTURY

DIAGONALS CARRY BOTH COMPRESSIVE AND TENSILE FORCES. VERTICALS SERVE AS BRACING FOR TRIANGULAR WEB SYSTEM.

LENGTH: 50-400 FEET
15-120 METERS

Figure 28. Warren Truss - Comp and Jackson

bridges. The Warren truss featured identical web members in which the loads alternated between tension and compression. In most later Warren trusses, the joints were riveted and not pin-connected. Whipple claimed to have built a Warren truss to his own design without knowledge of the British patent.

In 1847 Whipple published a book entitled A Work on Bridge Building[3] and this was followed in 1851 by Haupt's book, General Theory of Bridge Construction.[4] Because they provided the basis for analyzing truss structures, these books had a profound influence on American engineers and furthered the use of the iron truss for bridge-building.

Iron Horses and Iron Bridges

The 1850s saw the widespread use of iron trusses for railways, with each of the railways developing its own approach to bridge-building. In those antebellum days, each company designed, detailed, fabricated and erected its own bridges. Specialized engineering firms and fabricators for bridges were to develop later. Before the Civil War, the number of bridge firms was quite small and each tended to hold influence in a limited territory. Thus there was little of the "cutthroat" competition which developed several decades later.

A.P. Foller provides a contemporary view of railway bridge-building:

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[3] Whipple, Squire, An Elementary and Practical Treatise on Bridge Building, 1847

[4] Haupt, op. cit.

Through purely accidental causes, the three great railway systems of those days adopted three separate ideas of bridge building. The Baltimore & Ohio school, under the lead of Albert Fink and Wendell Bollman, developed the trussed suspension type, of which school Shaler Smith was a brilliant pupil; the Pennsylvania Railroad school, headed by Jacob H. Linville, (was) under the inspiration of the early writings of Squire Whipple and his pupil, John W. Murphy, who had settled in Philadelphia to engage in the building of bridges (since known as the Murphy-Whipple bridge), first with A.&P. Roberts and afterwards with Stone, Quigley & Burton, noted wooden bridge builders of the day; and the New York Central School, under the lead of George E. Gray, ... adopted the riveted lattice type through the influence, if I am not mistaken, of Howard Carroll (killed in battle during the war), one of his assistants, a brilliant young Irish engineer, who had been brought up under Sir John MacNeil and was therefore thoroughly imbued with English ideas. Mr. Hilton was also a pupil of Mr. Gray and an associate of young Carroll, and was very active in Americanizing the riveted lattice truss, and fastened for all time that type as the standard of the New York road. Outside of this road and the tributaries which it influences, the Whipple type (often erroneously called the Pratt), excepting for small spans, has been universally adopted throughout the country as the most economical and constructively the simplest, even as foreshadowed by the retiring and modest mathematical instrument maker (Squire Whipple), who, without precedent or example, evolved the scientific basis of bridge building in America. [5]

The Influence of the B & O Railroad on Bridge-Building

On July 4, 1828, at the same time the ground was broken for the C & O Canal by John Quincy Adams, a celebration took place in Baltimore to inaugurate the Baltimore and Ohio Railroad. Conceived as a railroad from Baltimore to the Ohio River, it was originally intended to be horse-drawn but switched to steam traction at an early time. This bold scheme, which was more than 20 years in

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[5] Foller, A.P., "Historical Sketch of the Development of American Bridge Specifications," Committee on Iron and Steel Structures, unpublished and undated.

completion, was essentially a commercial venture sponsored by business interests in Baltimore. However, it became much more than just a commmercial enterprise; it was a pioneering engineering work, on a grand scale, which had a significant influence on the development of engineering in the United States. When it was completed in 1852, the "Main Stem" was the longest main line service in the world, with an impressive list of major engineering accomplishments.

The pioneering railway began its bridge-building with monumental stone bridges and viaducts modelled on earlier British examples, but it soon became apparent that this was too slow and expensive, so an alternative was sought, first using timber and later iron.

The patented suspension truss bridges of Bollman and Fink attracted worldwide attention when the Baltimore and Ohio became the first railroad to adopt all-iron bridges as standard. Although scores of these patented bridges were built, the two most notable were in West Virginia--Bollman's Harpers Ferry Bridge (Figure 3, page 11) and Albert Fink's monumental Great Iron Bridge at Fairmont. Harpers Ferry, the scene of so much turbulent history in the Civil War, was the site of Bollman's most important structure, the Y-shaped bridge carrying the main stem of the B & O from Maryland across the Potomac to Virginia. This bridge was featured in John Brown's raid in 1859. Completed in 1852, the bridge was destroyed and rebuilt repeatedly during the Civil War. In its final form it lasted until the 1930s, together with a single-span Bollman truss across the Potomac power canal above Harpers Ferry. A sole surviving Bollman truss can be seen at Savage, Maryland.

Albert Fink improved upon the Bollman truss by rearranging the tension rods so that at each compression vertical the ties joined the strut at the same angle and did not tend to pull the strut out of the vertical as a result of temperature or live load stresses. The Fink truss became popular not only for bridge structures but for roof trusses, where many survive, hidden from public view (Figure 29 pictures an early example of a Fink roof truss, as used in the great B & O train shed in Wheeling in 1853).

Albert Fink's Great Iron Bridge at Fairmont was also destroyed in the Civil War and rebuilt (Figure 4, page 12). With three 205' spans, it was the longest iron railway bridge in the world at the time of its construction. Information on the bridge appeared in British and German engineering journals of the time.[6] The sole surviving Fink bridges known are at Lynchburg, Virginia, and on the grounds of the Phoenix Bridge Works in Pennsylvania.

Because B & O iron bridges were based upon an elaboration of the trussed beam, they were much more flexible than rigid truss bridges, thus becoming obsolete by 1875 because of the increased weight of locomotives on main line service.

C. Shaler Smith, the distinguished civil engineer, published in 1866 a Comparative Analysis of the Fink, Murphy and Triangular Trusses. In this he reported:

> Taking, therefore, all the points above reviewed into consideration, the conclusions would seem to be these, viz. that for all spans where the weight of the train is great

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6 The Fairmont Bridge has been nearly forgotten, along with Fink's other monumental bridges (historical material is needed on early bridge-building on the Baltimore and Ohio Railroad, featuring the work of Latrobe, Bollman and Fink).

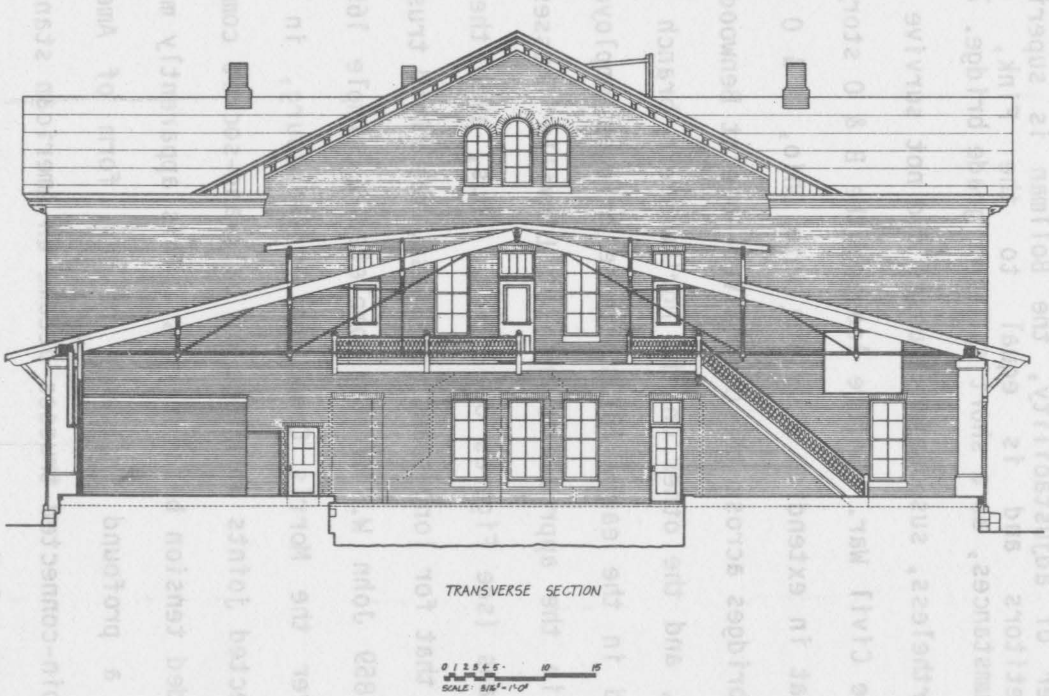

Figure 29. Fink Roof Truss at Wheeling - H.A.E.R. W.V. Survey

> in proportion to the weight of the truss, the Suspension trusses (there being in them no tendency to change of shape) are the best, and of these two the Fink is almost invariably preferable. This truss also ranks first for an undergrade bridge of any length of span, while for all overgrade bridges of more than 100 feet span the Triangular is the best truss. In perfection of principle, of action under a load, of general adaptability, and of compensation for the disturbing influences of temperature, the Fink stands first; in point of economical distribution of material, of proportional strength to weight of truss, and in first cost, the Triangular has the lead; while in the matter of adjustability, the Bollman is superior to its competitors and is equal to the Fink, under the circumstances, as a short span overgrade bridge. [7]

Nevertheless, suspension trusses did not survive the competition after the Civil War. Before leaving the B & O story, it should be noted that in extending its line into Ohio, B & O constructed two notable bridges across the Ohio River--one at Benwood, just south of Wheeling, and the other on the Northwestern branch at Parkersburg. Completed in the early 1870s, these bridges employed Bollman deck trusses in the approach spans but Linville trusses for the main river spans (see Figures 30 & 31). Thus, even the B & O tacitly admitted that for long spans, at least, the rigid truss was superior.

In 1859 John W. Murphy completed a simple 165'-span Whipple truss over the Morris Canal at Phillipsburg, in which he used pin-connected joints in place of ball-and-socket compression joints or threaded tension bars or rods. This apparently minor detail was to have a profound influence on the form of American bridges, because pin-connected trusses became an American standard until well into the twentieth century. Although pin joints lack the rigidity

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7 Smith, C. Shaler, A Comparative Analysis of the Fink, Murphy, Bollman and Triangular Trusses, New York, 1865.

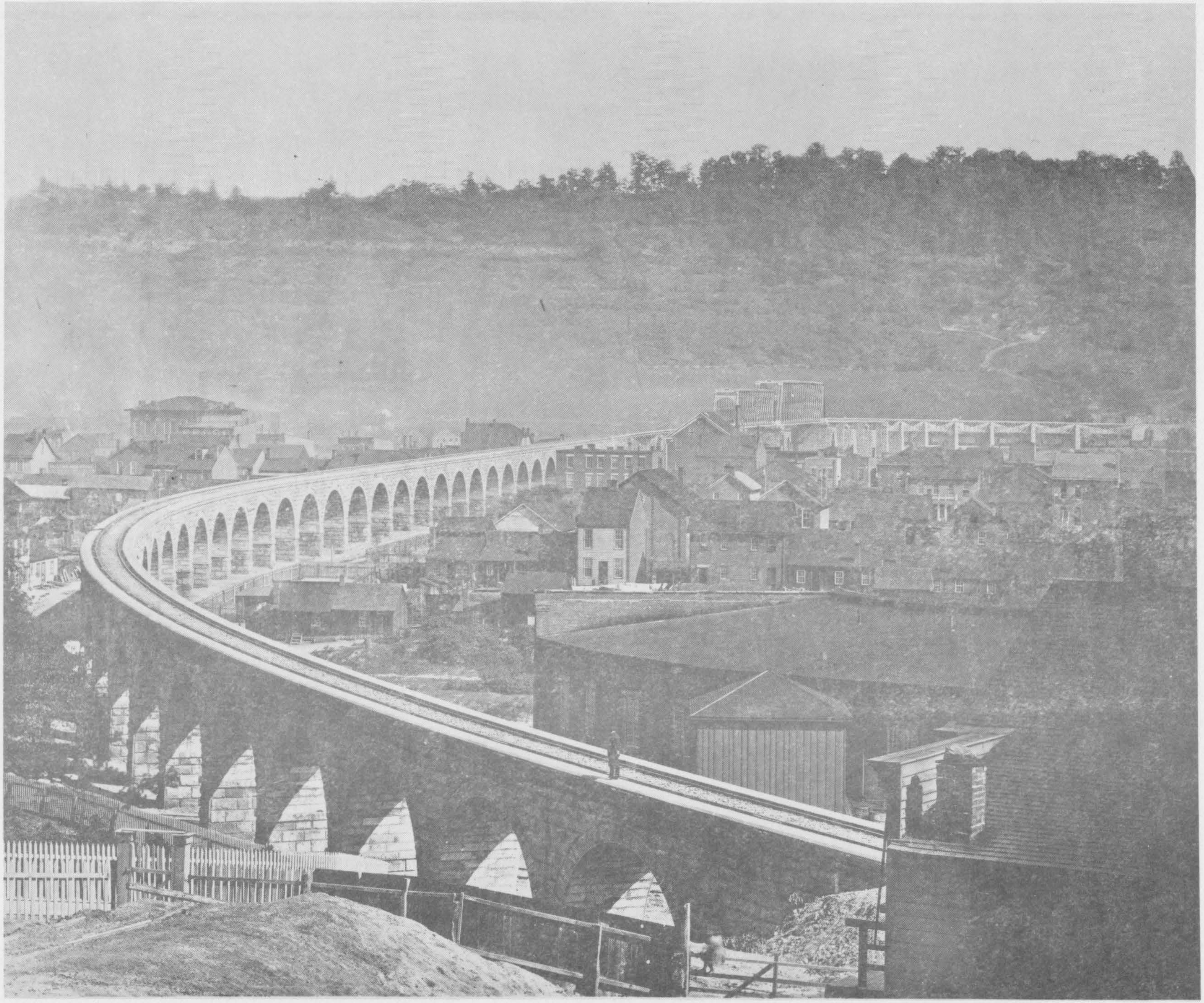

Figure 30. Benwood B & O Bridge - Smithsonian Collection

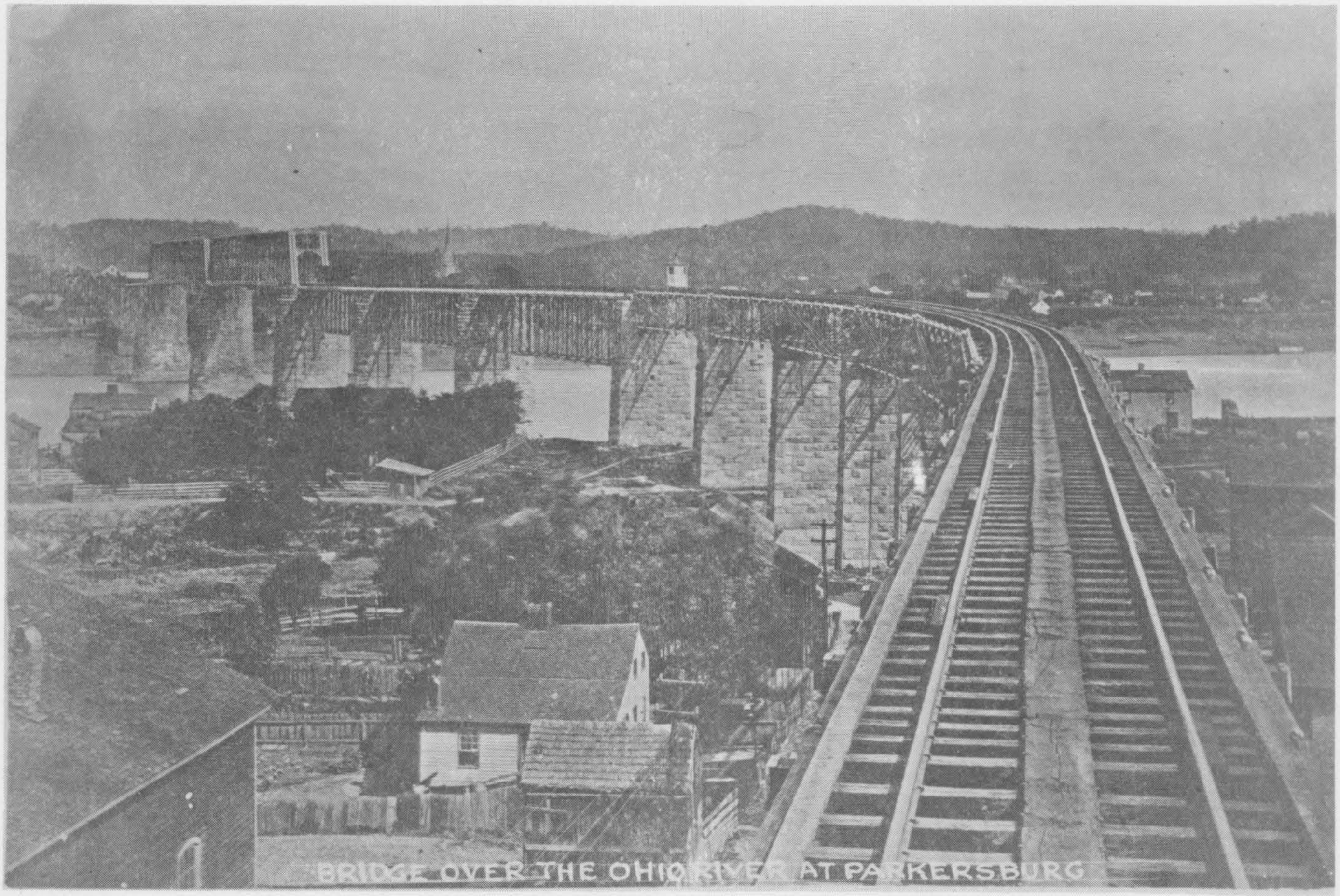

Figure 31. Parkersburg Bridge - Smithsonian Collection

of the riveted joint favored by the British, it is not difficult to explain the American preference for them. They simply eliminated the need for skilled workmen in the field. All fabrication could be done under controlled conditions in a fabricating shop, with only pins to be inserted during field erection. In this way, field riveting could be eliminated. A second reason, although much less important, was that the pin joint provided the assumed end conditions for each member, which insured that it was acting in direct tension or compression without secondary bending moments. This is the assumption made in determinant truss analysis, which of course assumes a free-turning, frictionless pin seldom achieved in practice.

During this period, Thayer (1845), Swartz (1857), Truesdell (1858) and many others continued to patent new truss configurations, including lenticular trusses, which received patents despite earlier European examples. The most notable lenticular truss is Lindenthal's Smithfield Bridge in Pittsburgh, completed in 1889 and still in service. None of these patented trusses was built in West Virginia.

Wire Suspension Bridges

Charles Ellet and the Wheeling Suspension Bridge

As noted, civil engineering did not spring fully formed from the head of Zeus as a scientifically originated profession. On the contrary, it had its origins in very humble manual crafts. However, the entire process of industrial development was accelerated by a few outstanding individuals who were able to infuse scientific principles and organizational skills into engineering.

Such a person was Charles Ellet, Jr., who was responsible for the introduction into North America of the long-span wire suspension bridge. A visionary who conceived a plan for the development of western rivers for navigation and flood control, Ellet made original contributions to the economic theory of railroad construction and operation and, in a larger sense, established principles for transportation economics. He and his son, Charles Rivers Ellet, made a significant although little-recognized contribution to the Union cause in the Civil War, especially during the Battle of Memphis, through construction and employment of a ram fleet on the Mississippi.

Ellet (1810-1862) received his early engineering training on inland navigation projects. As a result of a recommendation by Benjamin Wright, Ellet at age 17 first joined the Susquehanna Survey, in spite of his father's wish to keep his sons on the farm. A year later, in 1828, Ellet left the survey to join a new venture as an assistant. George Washington's original Potomack Company, chartered in 1785, had been formed with the intent of connecting the

Potomac and Ohio rivers. But, except for the canal and locks around Great Falls and other navigational improvements upstream on the Potomac, Washington's early dream had remained only a vision until the company was incorporated into the new Chesapeake and Ohio Canal Company, with construction under Chief Engineer Benjamin Wright. Ellet's native ability, coupled with hard work and willingness to assume responsibility, resulted in his rapid promotion to assistant engineer. This promotion must be considered exceptional, since he was not 20 years old and had little formal schooling and limited engineering experience, although, according to his mother, he had evinced considerable early talents for mathematics.

After two years with the Chesapeake and Ohio Canal project, Ellet decided to forego a move to Illinois, where part of his family had located and where there were excellent prospects for a young engineer, to take the unprecedented step of moving to France to study. This was to be the turning point of his life. He realized that this would be a loss of employment and field experience, coupled with the expense of a sea passage and living expenses. Nevertheless, he felt that going abroad was the best way to advance in his profession (throughout his life he was intensely interested in advancement and professional stature). While working on the Chesapeake and Ohio Canal, he had somehow found time to study foreign languages, and he was anxious to improve his French and have the opportunity to widen his liberal education through travel.

Ellet left for France in the spring of 1830 and, through a letter of introduction to Lafayette and the good offices of the

American ambassador, obtained admission to the famous Ecole des Ponts et Chaussees. He entered in November and left in the spring of 1831 for a tour of southern France and Switzerland.

The Ecole des Ponts et Chaussees was famous for the development of structural analysis and applied mechanics under the leadership of Gauthey and Navier. Navier (1785-1836) was noted as both an applied mathematician and a practicing engineer. Through the practice of engineering, and especially by means of his brilliant lectures, Navier succeeded in demonstrating how theoretical mechanics could be applied to the art of building. He had published several well-known texts, including a most significant work on suspension bridges in 1823,[1] which had resulted from his visit to England to examine the recently built chain bridges under appointment by the school's directeur general, M. Beequy.

Into this stimulating atmosphere stepped Charles Ellet. His exceptional early mathematical abilities, coupled with several years' experience, had prepared him to receive the maximum benefit from his brief sojourn. Since Ellet was born at Penn's Manor near Philadelphia, he may well have been familiar with the world's first wire suspension bridge--the footbridge over the Schuylkill built in 1816 by White and Hazard--or even one of James Finley's early iron chain suspension bridges. However, it seems most likely that Ellet received his inspiration and enthusiasm from Navier, who had been promoted to professor in 1830. While, strangely, he does not

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[1] Navier, C.L.M.H., Memoire sur les ponts suspendus, Paris, 1823.

mention Navier by name in any of his extant correspondence, Ellet did mention him in later engineering reports.

For more than two decades following his sojourn to France, Ellet was an enthusiastic promoter of suspension bridges. His contributions to American preeminence in long-span suspension bridges are twofold--first, promotion of the principle of suspension bridges, and second, production of plans and designs and building of suspension bridges. His active promotion of the principle was through a series of bold and innovative proposals for long-span bridges at Washington, Philadelphia, St. Louis, Niagara and in Connecticut. In these published reports, Ellet lucidly presents the principles involved and verifies them with historical information on existing structures in Europe. He also carefully sets out design details and cost estimates.

Despite earlier failures, the use of the suspension principle was of compelling interest to engineers for several reasons. From the engineering point of view, Navier had published a simple and accurate method for analyzing such a structure without stiffening trusses and subjected to static loads. It was not until Haupt's and Whipple's treatises on bridge analysis appeared in the 1840s that engineers could analyze truss bridges.

In an age when large rolled wrought iron sections were not available and cast iron members were limited in size and tensile capacity, the possibility of utilizing a superior material such as drawn wrought iron wire was most attractive. Its availability permitted a few engineers of Ellet's ability to envisage long-span

bridges in excess of 2000 feet of clear span. Ellet argues succinctly in his Wheeling Bridge Report of 1847 for the suspension bridge principle.

Equally important was the economy derived from utilizing a superior material in the most efficient manner--*i.e.*, drawn iron wire in tension. In addition, the suspension principle eliminated the need for river piers for single-span structures. This was a great economy in the days of hand labor, before the advent of the pneumatic caisson in America.

Ellet was well aware of the problems of deflections and vertical stiffness of a suspension bridge, as evidenced by his proposal for the Mississippi Bridge at St. Louis, in which he discusses the lateral stability of suspension bridges subject to wind loads. He uses the most current information available on wind pressure to show that the projected area of a suspension bridge is usually so small that a properly designed bridge could resist such loads even if the deck were assumed to act as a pendulum. In spite of evidence at the time of a number of bridge failures caused by wind action, Ellet did not realize that the problem is a dynamic one, involving torsional resonance vibrations of the deck and not merely the ability of the structure to resist static lateral loads. (The lack of understanding of the dynamic response of suspension bridges was to plague this type of structure throughout its history, with the latest major victim the ill-fated Tacoma Narrows Bridge.) As will be noted, Ellet was to pay dearly for this inherent weakness of the unstiffened suspension bridge.

In all likelihood, Ellet was the first to advocate the use of conventional suspension bridges for rail traffic. Rail suspension bridges were proposed by Ellet in 1848 for the bridge across the Connecticut River,[2] and again in his second proposal for a bridge across the Potomac at Washington. He advocated provisions for rail traffic in many of his publications and sought the means to rebuild the Wheeling Bridge in 1854 to carry rail traffic.

The second aspect of Ellet's contribution to long-span suspension bridges was the complete designs he proposed and the bridges he built. He was essentially a man of action. Thus his written works should be viewed as supportive of his professional activities and his sweeping vision of internal engineering improvements for the entire nation.

Ellet returned to the United States early in 1832. In August the United States government advertised for the construction of a bridge across the Potomac. Ellet submitted his proposal, including an estimated cost of $518,528, for a bridge of 600 feet in span, with a clear distance between piers of 582 feet. The deck was to be 46 feet above low water.

The proposal was quite revolutionary in America for its time. Even if his proposal had been submitted on time, it probably would not have been considered favorably. The government, in its wisdom, decided to repair the old wooden bridge. Thus both Ellet and the

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[2] Ellet, Charles, Jr., <u>Report on the Connecticut River Bridge</u>, 1849.

nation missed the opportunity of building what Ellet described as a monumental structure of "grandeur and beauty."

With the rejection of his proposal, Ellet accepted a position, under Benjamin Wright, to survey the western line of the New York and Erie Railroad. He later joined Wright as an assistant engineer of the James River and Kanawha Canal and in 1836 was appointed chief engineer. During this period Ellet wrote An Essay on the Laws of Trade, a publication that was circulated widely in its day and is now receiving increased attention by scholars of antebellum economic theories. As a result of a clash of personalities with several of the canal directors, Ellet was not reappointed in 1839 and left the company in May of that year.

In 1840 Ellet submitted a detailed proposal and cost estimate for what would have been the most spectacular bridge in the world, the Mississippi River Bridge at St. Louis.[3] The length of the bridge from abutment face to abutment face was 3000 feet, with the longest of the three spans 1200 feet (Figure 32 shows Ellet's elevation of the proposed bridge). He spent the autumn of 1839 preparing the report, which was to be his most comprehensive publication on suspension bridges, considering all aspects of the design and construction of the huge bridge.

Ellet's detailed proposal for the foundations, which were to rest on piles and, in the case of the river piers, were secured by a

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3 Ellet, Charles, Jr., Report on the Mississippi Bridge, Philadelphia, 1840. It should be noted that this proposal was submitted 34 years before the completion of the famous Eads bridge.

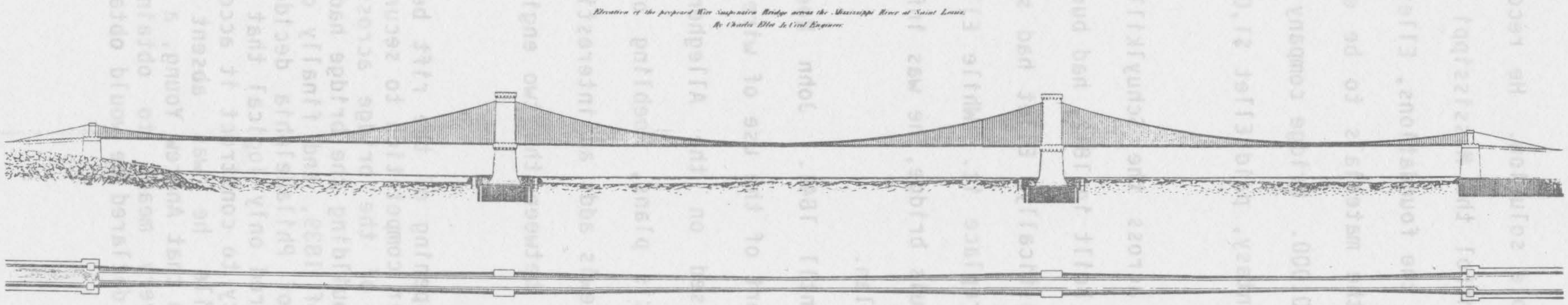

Figure 32. Ellet's Mississippi River Bridge

cut-waters, appears to be a feasible solution. He recognized the great problem of attempting to control the Mississippi during and after construction. In addition to the foundations, Ellet described the cables, towers and deck and the materials to be employed in each. He estimated the cost at $600,000. Bridge company directors, who considered the proposal pure fantasy, paid Ellet $1,000 for his services and dismissed the matter.

Lewis Wernwag's famous bridge across the Schuylkill River at Philadelphia, "Colossus," which was built in 1812, had burned during the summer of 1838 and, characteristically, Ellet had submitted a plan for a suspension bridge to replace it. While Ellet was in Illinois, concerned with the St. Louis bridge, he was informed that the commissioners had approved his plan.

Construction did not start until 1841. John Roebling had written Ellet earlier for his support of the use of wire rope as a substitute for the hemp rope used on the Allegheny Portage Railroad. After approval of Ellet's plans, Roebling offered his services to Ellet as a designer. Lewis adds an interesting insight into the rift that later developed between the two engineers over the bridge:

> The real reason for the opening of the rift between the two bridge builders was their competition to secure the contract for the construction of the bridge across the Schuylkill. Ellet's plans for building the bridge had been accepted in the early summer of 1839, and finally during the spring of 1841 the city of Philadelphia decided to construct the bridge. It appeared only logical that Ellet should be granted the opportunity to construct it according to his plans. However, while he was absent from Philadelphia, his wife wrote him that Andrew Young, a local contractor, was exploiting every means to obtain the contract. She reported that he declared he would obtain it

even if he lost $20,000 in the bargain. In April 1841, according to Steinman, the contract was awarded to Young and, realizing his incapacity, he hired Roebling to be the engineer for the construction of the bridge. Roebling wrote Ellet that he was 'very desirous of superintending' the building of the bridge, but that he would abstain from all dishonorable interference. He declared that Young had told him that Ellet had refused to join him in a partnership to construct the bridge.

Ellet's correspondence does not reveal the reason the county commissioners rescinded Young's contract in June and awarded it to Ellet, but Steinman quotes a letter from Young to Roebling explaining the situation. 'I have been most shamefully cheated out of the Contract for the Bridge,' he wrote,'--by the influence of Johnston the County Commissioner and the course that Ellet pursued--he went underhandedly and offered to take, from the men that subscribed, lots as payment for work done. By this means, a majority in the County Board were influenced to vote for him to get the Contract. It is considered one of the foulest acts that has ever been committed in the City of Philadelphia'[4]

Ellet's Fairmount Bridge, America's first important wire suspension bridge, served successfully for 33 years and was replaced in 1874 by a new bridge which could accommodate the increased traffic (see Figure 33).

Shortly after his return from France, Ellet had visited the Niagara Gorge for the express purpose of studying the site for a possible suspension bridge. The location was magnificent and the completion of a bridge over this gorge would bring world renown to the man responsible. Ellet and others were interested.

From 1845 to 1847 the rivalry between Roebling and Ellet was intense. Award of the contract for the Wheeling Bridge in July 1847 undoubtedly helped Ellet's cause, and he was awarded the Niagara

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[4] Lewis, Gene D., Charles Ellet, Jr. University of Illinois Press, Urbana, Illinois, 1968, pp. 72-77.

Figure 33. Ellet's Fairmount Bridge - Smithsonian Collection

contract in November, thus becoming engaged on two major bridge projects at the same time.

Ellet constructed a pedestrian bridge over the gorge. However, his increasingly strained and very complicated dealings with the two bridge companies resulted in Ellet's dismissal as engineer.

Ellet started construction of the Wheeling Bridge over the Ohio in 1847 and completed it in December 1849 amid great public acclaim. He describes the structure in his proposal of 1847:

> The Description of the Bridge
>
> The span of the Wheeling bridge is 1010 feet from centre to centre of the supporting towers. The height of the flooring, at its greatest elevation, is 97 feet above the low water surface of the Ohio.
>
> The highest freshet ever known at this point was that of 1832, when the river attained an elevation 44 1/2 feet above its lowest summer surface.
>
> The flooring of the bridge will be high enough to permit a steamboat, with a pipe 50 feet above the water, to pass at the top of the flood. But as the freshet of 1832 was 6 feet higher than the highest ever known before or since, it is impossible that the navigation can suffer any appreciable interruption, in any stage of the water, from the construction of this work.
>
> The summit of the eastern tower is 153 1/2 feet above the abutment by which it is supported and 21 3/4 feet above the summit of the western tower.
>
> The flooring is 24 feet wide, with two foot-ways, each 3 1/2 feet wide, and an intermediate carriage-way 17 feet wide.
>
> The level of the roadway at the eastern abutment is 93 1/2 feet above low water, at the western abutment 62 feet, and at the highest point, near the eastern shore, 97 feet. From this highest point it descends towards the island at the rate of 4 feet in 100, or on an angle of 2 1/3 degrees, and towards Main Street, in the city of Wheeling, at the rate of 3 93/100 feet in 100, or on an angle of 2 1/4 degrees.

The western slope of the flooring is continued as far as the roadway on the island, at which point an embankment will be required 10 feet high.

The flooring is supported by 12 cables of iron wire, each of which will be about four inches in diameter and 1380 feet long.

The cables rest on iron rollers placed on the summits of the columns, the movement of which will effectually relieve the towers of the strain which would be occasioned by the contraction and elongation of the stays, consequent on variations of temperature, or the transitory loads brought on the flooring.

The stays are anchored into the masonry of the wingwalls on the western shore and into other appropriate walls devised for the purpose under Main Street in the city.

The angle formed by the stays with the axis of the columns is very nearly the same as that formed by the tangent of the curve, on the opposite of the towers, with the same axis, so that the weight of the bridge, and that of the loads which may be brought on the platform, will be directed along, or nearly along, this line and, consequently, produce no horizontal action at the summit, tending to overthrow or disturb the columns.

This resultant, however, does deviate somewhat still more, but that the towers depart from the vertical as much as is necessary to bring the resultant of all the forces, including the moment of the towers themselves, in the centre of the base.

This is by no means absolutely necessary--for we have a right to count on the inertia of the supporting towers--but as every part of a structure of this character is adjusted with a view to a permanent and stable equilibrium, it ought to be the effort of the engineer not only to obtain entire security, but the greatest permanence and strength that can be procured by the application of a given amount of money and material.[5]

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5 Ellet, Charles, Jr., Report of the Wheeling and Belmont Suspension Bridge, Philadelphia, 1847.

With a 1010-foot main span, the Wheeling Bridge was for many years the longest bridge in the world (Figure 34 shows an early drawing of the bridge by Ellet). In 1854 a violent windstorm blew the bridge down. Ellet was called in [6] to rebuild the bridge, which was opened three months later as a temporary one-lane structure. The complete rebuilding of the deck was completed in 1860. Alterations were made in 1872 by Washington Roebling, whose addition of wire rope stays effectively "Roeblingized" the bridge, and this is the way it appears today (see Figures 35 & 36). Since the nineteenth century, several renovation schemes have resulted in new decks (the current steel grating was installed in 1956). The masonry towers, anchorage and approaches are all original and all but four of the cables were salvaged after the storm and reused. The suspenders and iron truss fittings date from the 1860 rebuilding of the bridge deck.

In 1982 the bridge was again rehabilitated. The cables were unwrapped and thoroughly inspected, together with the saddles and anchorages. Although the cables remain in reasonably good condition, additional wires were spliced in at the saddles and in at least one anchorage where broken wires were discovered. The cables were rewrapped with a "neoprene" covering, the suspenders to the 1956 open grid deck remounted and the wood in the Howe stiffening truss renewed.

Designated as both a national and international historic

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6 Not Roebling as indicated by Steinman, D.B., <u>The Builders of the Bridge</u>, Wilmington, Ohio, 1972.

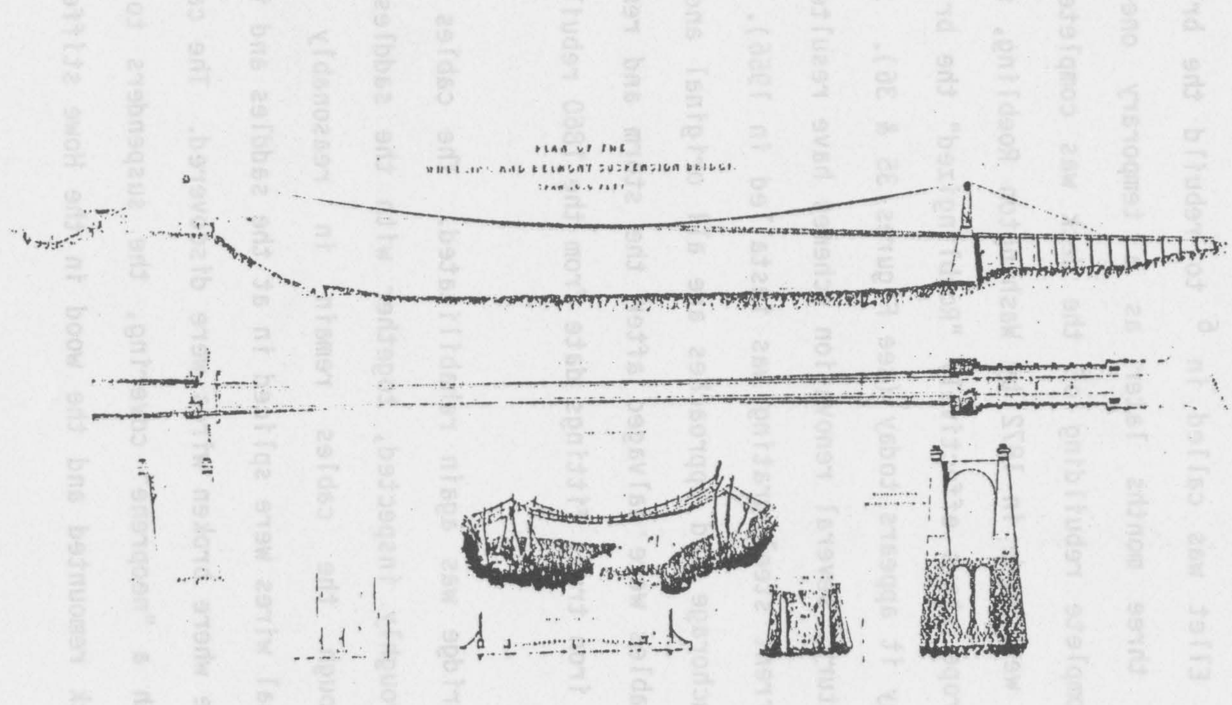

Figure 34. Ellet's drawing of the Wheeling Bridge

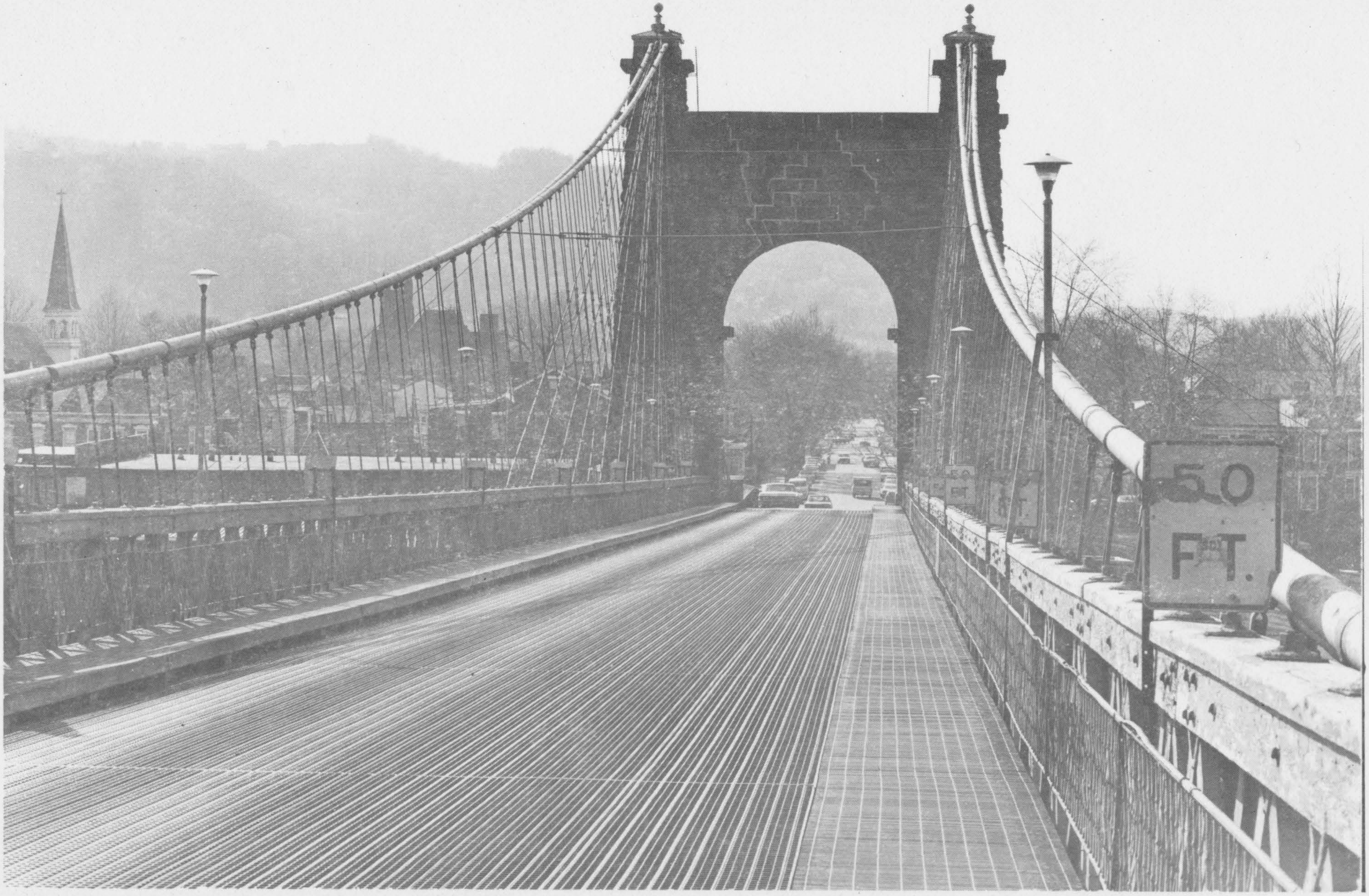

Figure 35. Wheeling Bridge, general view from deck - William E. Barrett

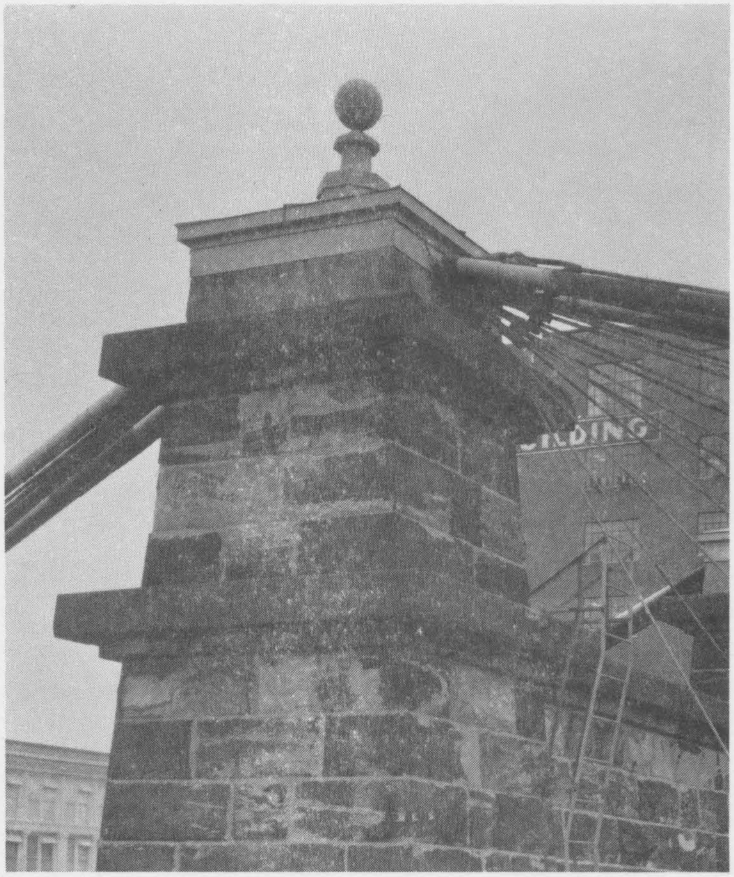

Figure 36. Wheeling Bridge, tower details - William E. Barrett

landmark, the bridge is the most important antebellum civil engineering structure extant in North America. West Virginia's most important historic landmark is a fitting tribute to Charles Ellet, Jr.

<u>A Case for Technology Transfer</u>

The completion of the Wheeling Suspension Bridge in 1849 caught the attention of engineers, and indeed the public at large, as one of the great triumphs of bridge-building. Its significance was not lost on the Virginians in the region across the mountains from the Old Dominion. All of the reasons which made the Wheeling bridge a success, both technically and economically, were applicable to bridge sites across major tributaries of the Ohio River. Thus in the 1850s important suspension bridges were built across the Monongahela River at Fairmont and Morgantown, across the Cheat at Albright on the Brandonville-Evansville Turnpike, across the Elk River at Sutton on the Weston and Gauley Bridge Turnpike, across the Elk at Charleston and across the Guyandotte near Huntington. The technology spread to Ohio, where the Dresden Bridge was completed in 1853. There may well have been more wire suspension bridges which have vanished, leaving only slight traces of their existence to be discovered in obscure county archives. The only span remaining is the Wheeling Bridge, which spawned these other bridges before the Civil War.

Not only was the conception and design of these bridges the same, but in many, if not all, the wire was supplied from Wheeling and the cables were laid up by workmen who had gained their

experience on the Wheeling Bridge. Resemblance to the Wheeling Bridge can be seen clearly in the cable, stiffening truss and saddle details of these bridges (see Figure 37-41 for illustrations).

Of these other bridges, the first to be erected, in 1852, was the suspension bridge at Fairmont. It had a span of 550 feet, with 30-foot towers. The contract for the wire went to Dewey and Co. of Wheeling. In 1850 the Morgantown Bridge Company had been incorporated by the Virginia Assembly, and construction on a wire suspension bridge was begun in 1853. Contracts were signed with Kelly and Kennett of Fairmont for the stonework, John Downey of Wheeling for the cables and Dewey and Co. for the anchors. This bridge, which had a span of 608 feet, served the community well until it was demolished in 1909.

The suspension bridge over the Elk at Charleston was begun in 1851 by an incorporated company of Kanawha County, with wire and anchor irons furnished by E. C. Dewey of Wheeling. The bridge, which had a span of 478 feet and 30-foot towers, suffered greatly during the Civil War. In 1861 Confederates, retreating south, partly cut one of the cables, but this was repaired by the Union forces who occupied the valley. In 1862 Union troops made a hasty retreat toward the Ohio and cut one of the cables, completely wrecking the bridge. No attempt was made to repair it until the end of the war in 1865, when the company rebuilt it. The bridge later became quite well-known because of the catastrophic failure of one of its anchorages in December 1904, killing two people and plunging many others into the icy river. The Guyandotte bridge, built in 1853, had a span of 540 feet.

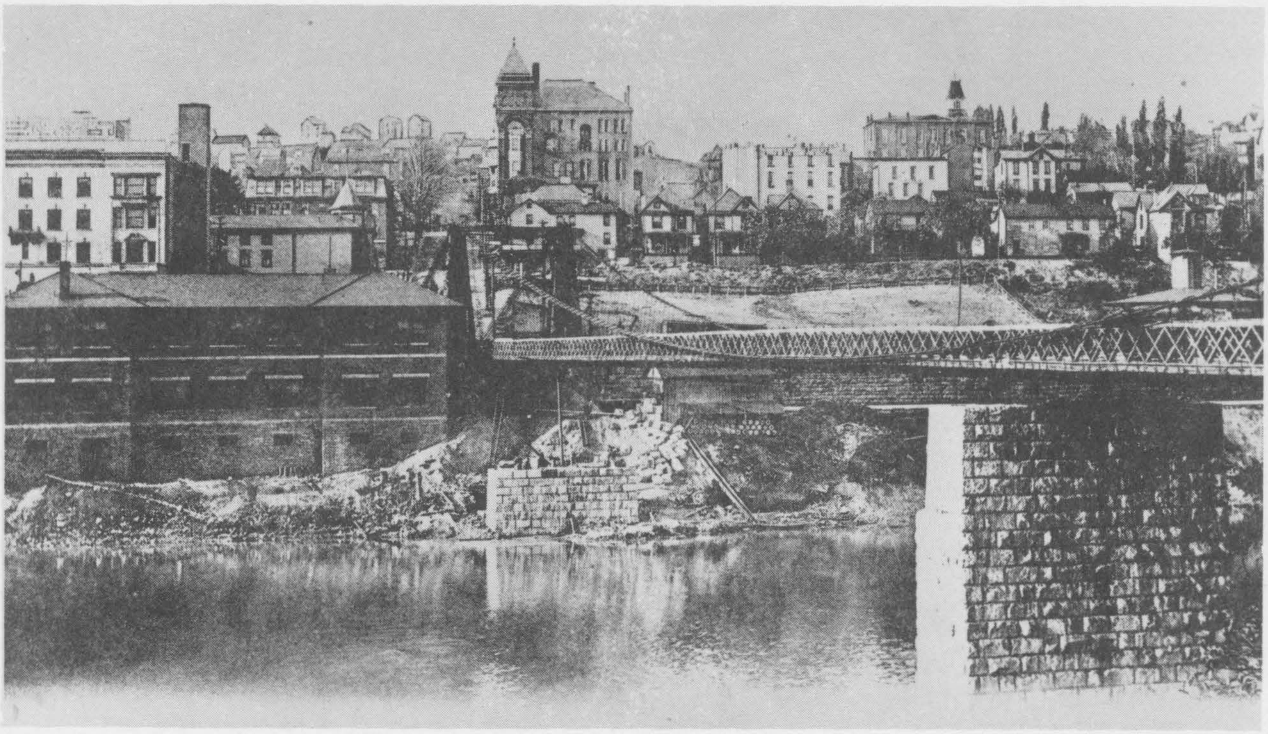

Figure 37. Suspension Bridge at Fairmont

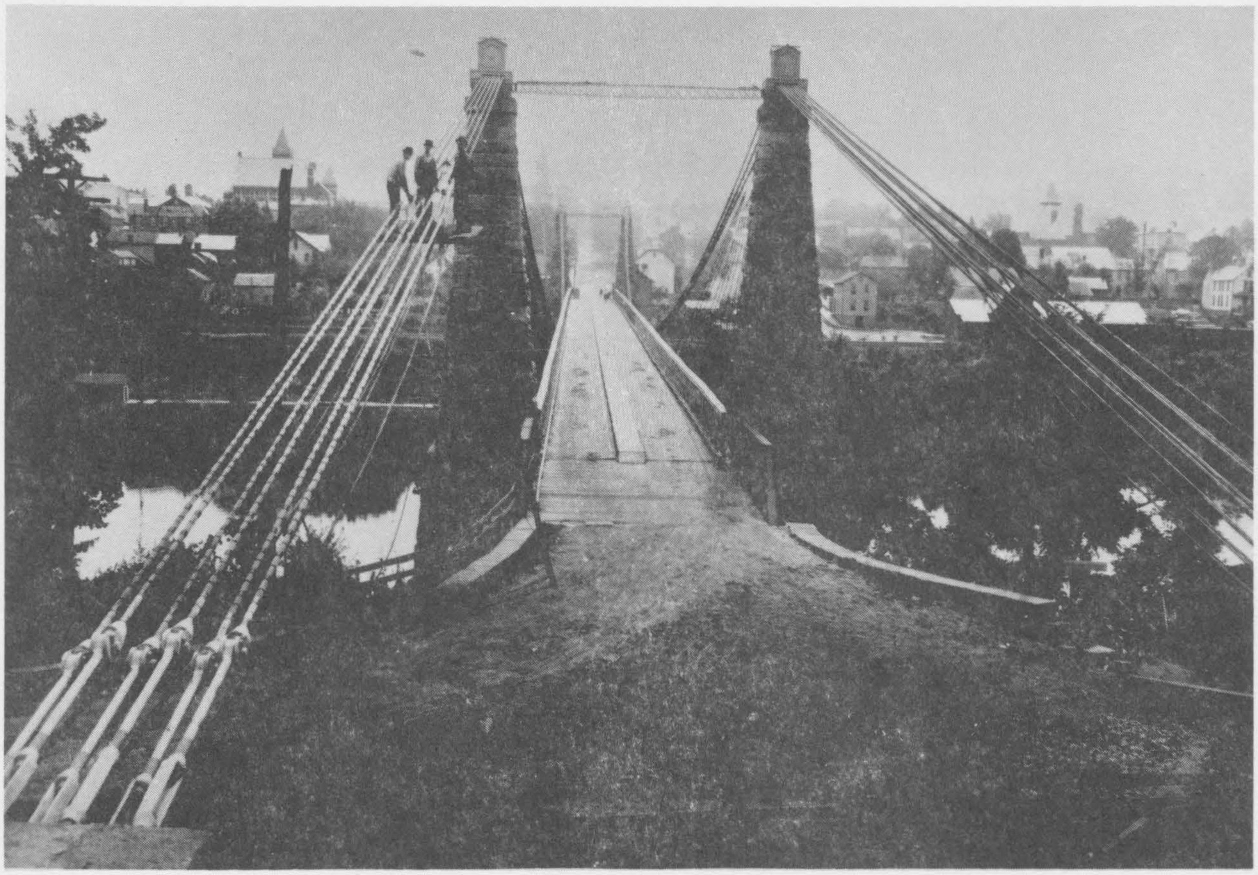

Figure 38. Suspension Bridge at Morgantown

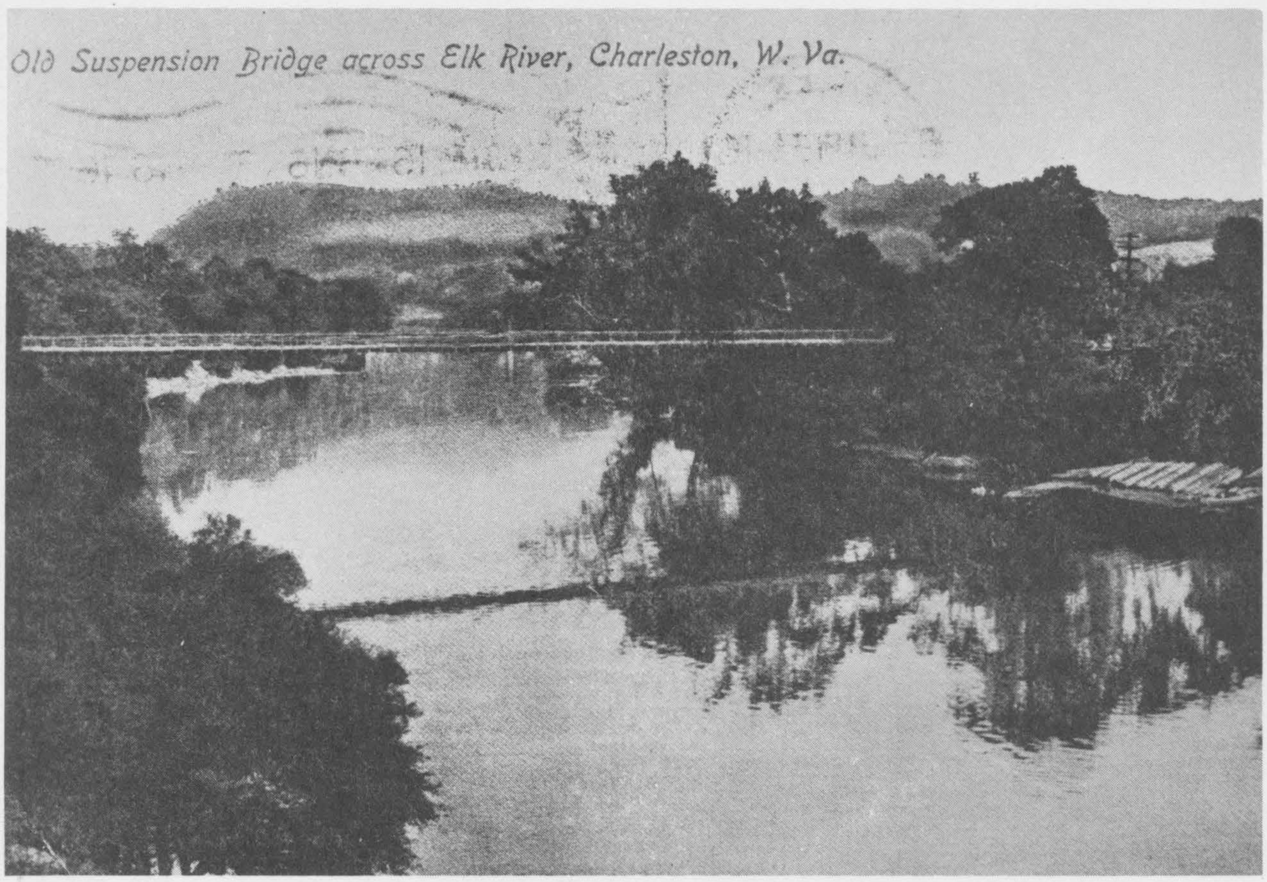

Figure 39. Old Suspension Bridge Across Elk River, Charleston, WV

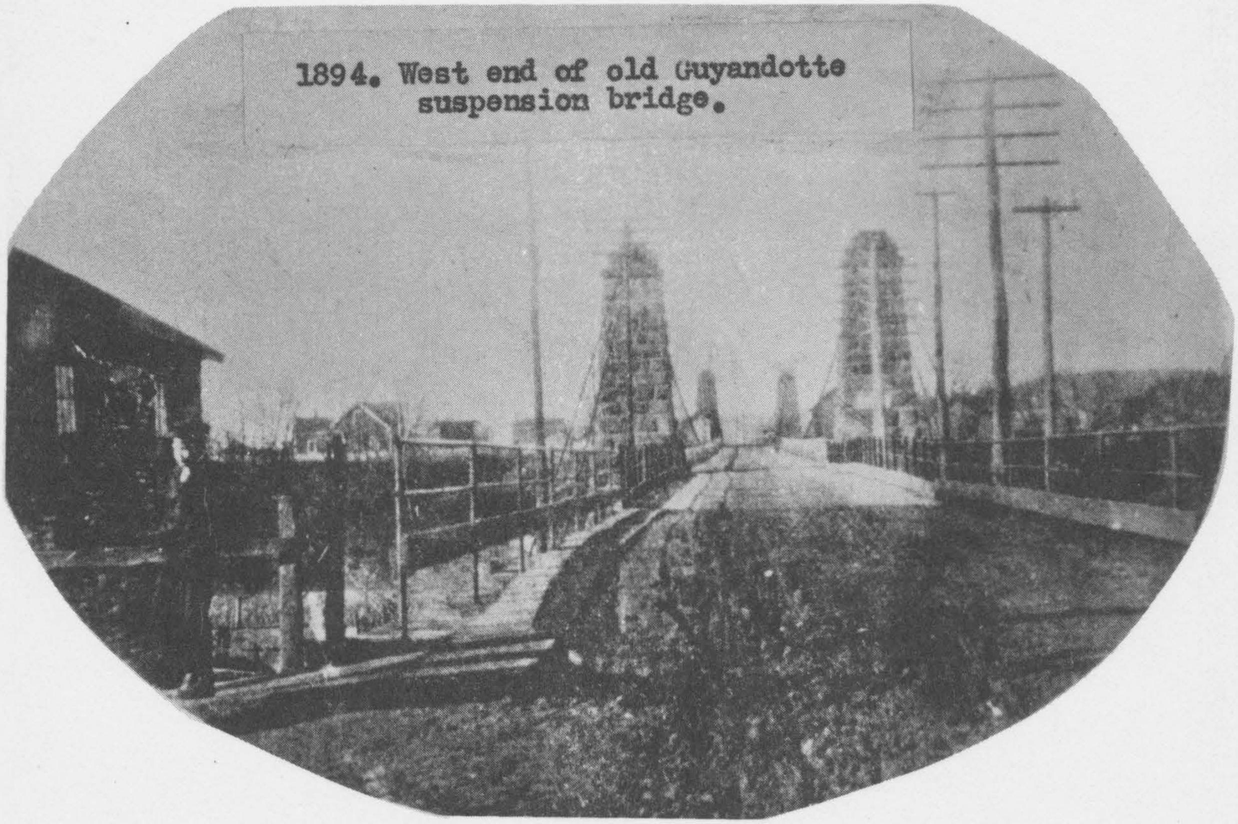

Figure 40. Suspension Bridge over Guyan River at Huntington

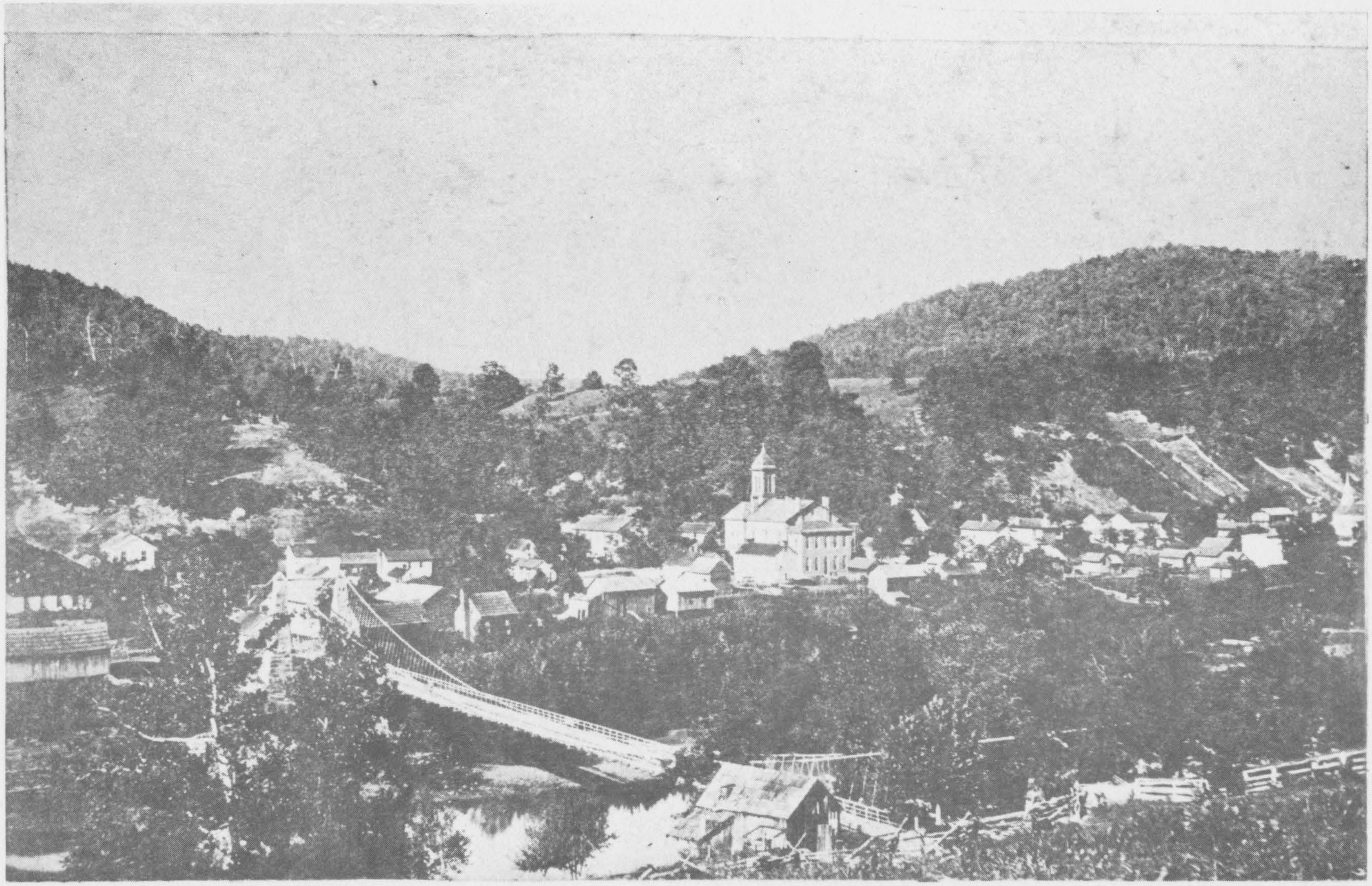

Figure 41. Suspension Bridge at Sutton - Craig Smith Collection

The construction of the wire suspension bridge at Sutton provides a useful case study of the difficulties of constructing bridges in rural areas:

> On June 7, 1853 in Sutton, a contract was let to Ira Hart "for building a bridge over the Elk River on the Weston and Gauley Turnpike at the point selected by the turnpike" for his bid of $8,448. He was to construct a bridge on the "Trestle suspension plan, similar to that on the B & O Railroad over the Cheat River." (This would mean that they were proposing a Fink truss bridge.) For some reason which is not now clear, it was decided to alter the plans for this bridge and on July 23, 1853 this contract, with the consent of Hart, was set aside. A new contract was made with Hart "to build a wire suspension bridge over the Elk River on said road, to be at least three hundred feet long and warranted to sustain fifty tons equally distributed, for which the company is to pay the said Hart the sum of $9,500." Hart was to enter into a bond of $10,000. At this point Hart sublet the stonework and went himself to Wheeling to purchase the necessary wire. . . . from Bodley and Company, who made the wire and the fixtures for the Wheeling Suspension Bridge built in 1849, and employed Mr. Downing who had laid the wires for the Wheeling, Nashville, Charleston, Fairmont and other suspension bridges. On October 3, 1853 Hart took his bond to the Board, which for some reason was refused and his contract set aside although his bond was accepted for the Little Kanawha Bridge. The Board claimed that they did not know the signers of his bond. Then, on October 4, the Board signed a contract with Benjamin W. Byrne "to construct a wire suspension bridge over the Elk River on said companies' road agreeably to the specifications filed by J. S. Camden, a superintendent of said road, for which the Company is to pay to said Byrne $12,000." This bridge was to be longer, being 460 feet from center to center of the towers, 33 feet high and 17 feet wide. Ira Hart was understandably annoyed and wrote to the Board of Public Works on November 1st, 1853 to complain that he had begun work on his contract in good faith and could not understand why his bond had not been accepted. The Board of Public Works acted on his part and instructed the directors of the Weston and Gauley Bridge Turnpike Company on November 9, 1853 to rescind the contract with Benjamin Byrne and restore to Ira Hart his contract of July 23, 1853. The Board of Directors of the Weston and Gauley Bridge Turnpike met on December 6, 1853 to carry out the Board of Public Work's wishes but they felt that the July contract with Hart was insufficient. Since Byrne had already built an abutment on the north side of the river, they decided, with

> the agreement of Hart and Byrne, that Hart should build a bridge to the same specifications as the one agreed to by Byrne, using the abutment already built. Hart was to be paid $11,500, and Byrne was to be paid $1,600 for work already done. The bridge was to be constructed by December 25, 1854.[7]

These early suspension bridges proved unsuitable for traffic conditions in the 20th century and were all replaced before the First World War.

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7 Kemp, <u>Building the Weston & Gauley Bridge Turnpike</u>, pp. 325-328.

Catalogue Bridges

Standardized Designs

For generations, students have been taught history that is punctuated by battles which divide the subject into convenient periods. In the case of bridge-building, this is exactly what the Civil War did, since the modern period of bridge-building really dates from the 1870s.

At mid-century, engineering specifications as we now know them did not exist. For railways, the loading was usually specified per lineal foot, but allowable stresses were not specified, nor were equations or procedures given for proportioning members. At the close of the Civil War, several railroad companies prepared specifications for their own internal use. This situation could be tolerated as long as the bridges were designed, fabricated and erected by the railroad company itself but, when specialized bridge companies were asked to submit bids on a particular bridge, there was no common basis for evaluating the bids.

When Octave Chanute, of aircraft fame, served as chief engineer of the Erie Railroad in 1873, he was responsible for the first published set of bridge specifications. These emphasized loading requirements for bridge design and little else. Materials testing was still in a primitive state during this period, in spite of the fact that extensive testing had been done in England in the 1840s in connection with Stephenson's great Britannia Bridge. There was virtually no quality control on structural iron work. Cast iron in particular was subject to great variations in strength, and defects

were all too common in structural cast iron members. Little wonder that safety factors as high as eight were used for cast iron columns.

For the remainder of the century, railways provided the leadership in bridge-building, outside of the development of the suspension bridge, which was considered too flexible for rail service and found little use, with the notable exception of Roebling's Niagara and Brooklyn bridges.

In studying the history of 19th century building, three major American achievements emerge--namely, the metal truss bridge, the long-span wire suspension bridge and the skeletal framed skyscraper. Historians concerned with the history of building have pursued these three structural forms vigorously, documenting and evaluating the major accomplishments in each,[1] and the American contribution is indeed impressive by any standard. This concern for monumental works, however, has eclipsed another uniquely American phenomenon that in many ways has a much clearer American stamp on it: the catalogue bridge.

Unlike the central control of engineering works, which came to be the hallmark of French civil engineering practice, there was virtually no federal guidance, control or support in the development of the nation's highway system, the notable exception being the National Road. In Virginia the Board of Public Works was responsible for the turnpike system. The three major turnpikes

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[1] A selected bibliography is included in Appendix A to provide a more comprehensive view of structural engineering history in the 19th century.

could be considered part of a statewide system, but the turnpike movement really must be viewed as a "bootstrap" operation in which dozens of local turnpike companies were founded to open up relatively small areas. Many were ill-conceived and failed to turn a profit. Increasingly, the Board of Public Works reacted to the building of roads rather than initiating it. Through its matching grant system, the Board of Public Works did, however, retain loose control on the design and building of roads.

Following the Civil War, both Virginias were unable to continue the turnpike system. The existing roads, many of them in a deplorable state following the war, were turned over to county courts for administration. Thus, the great surge of bridge-building was left in the hands of county, township and municipal authorities with limited vision, resources or expertise.

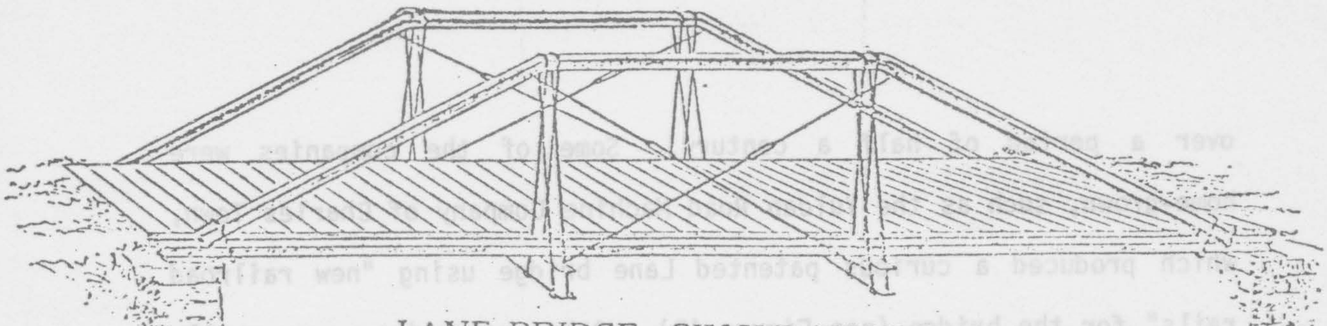
To meet this large potential market, bridge fabricating companies sprang up like weeds. There were literally hundreds in business from mid-century to the Great Depression (see Appendix B). Some, like the Keystone Bridge Company, were leading firms involved in major projects, but the vast majority were small firms producing standardized designs for short- and medium-span bridges. In many cases the product line was built around some patented bridge system. These companies produced illustrated catalogues which could be used by company salesmen to sell highway bridges. The pin-connected Pratt truss was without question the most popular on a nationwide basis.

In West Virginia alone, more than 50 bridge companies and nearly 100 additional bridge builders were involved in building bridges

over a period of half a century. Some of the companies were home-grown, such as the Vulcan Road Machine Company of Charles Town, which produced a curious patented Lane bridge using "new railroad rails" for the bridge (see Figure 42). Other companies were equally obscure, such as the West Virginia Bridge Company or the Marion Machine and Foundry Company. The majority, however, were out-of-state firms, with Ohio the clear leader in the number of bridges constructed and the number of companies represented. (It appears that all of the larger towns in Ohio had at least one bridge company.) Of the companies which built bridges in West Virginia, among the leaders were the Keystone Bridge Company, the Canton Bridge Company, the Wrought Iron Bridge Company, the King Bridge and Iron Company and the American Bridge Company, a subsidiary of the U.S. Steel Corporation formed under the leadership of Andrew Carnegie and others by merging 28 bridge companies.

A period of intense competition followed. With little regulation, designs were produced using the least amount of material, with little regard for good engineering practices, and inspection of the erection or building of the abutments was usually neglected. Nevertheless, many of these bridges, which flourished from the 1880s until the end of the first decade of the 20th century, remain in service today.

While even a brief history of leading 19th century companies that built bridges in West virginia is impossible, some impression of the practice of bridge-building can be gleaned from the following excerpt from the history of the Champion Bridge Company of



LANE BRIDGE—SINGLE TRUSS.

Built in spans of 15 to 36 feet.

(15 to 25 feet, two panels; 26 to 36 feet, three panels.)

We use NEW Steel Railroad Rails for Lane Truss Bridges and second hand rails for foundations.

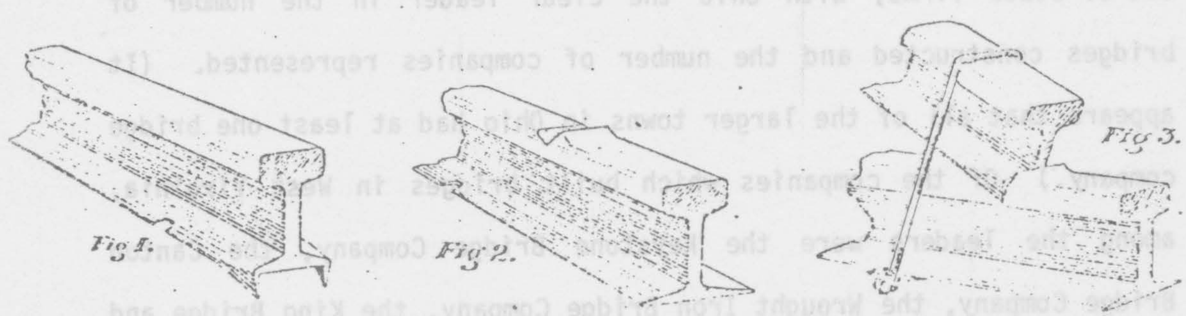
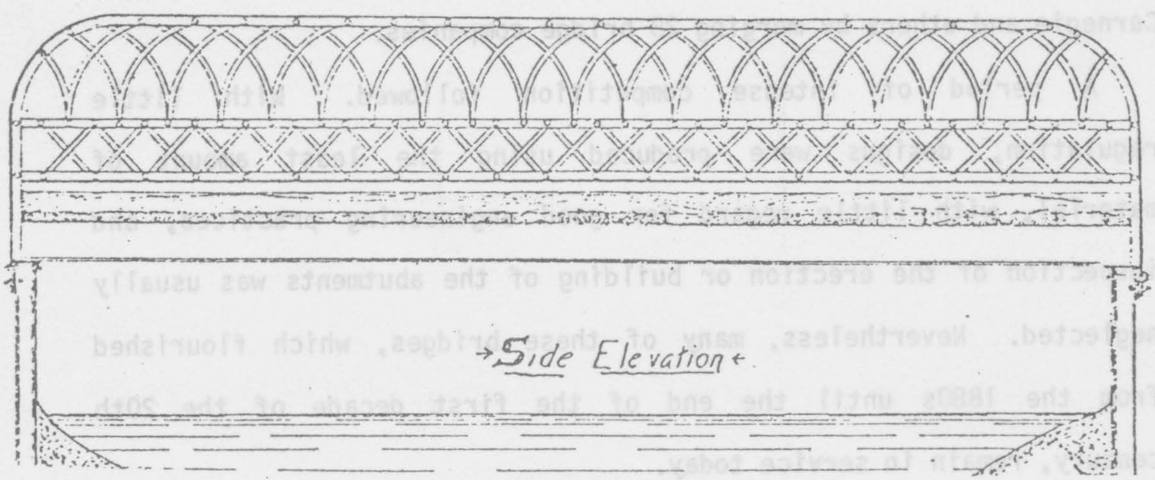


Figure 1 shows end of top or Truss Beam. Fig. 2 shows bottom or Chord Beam with raised shoulder. Fig. 3 shows the two in place. All of our bridges are bolted to wall plates if on stone, and to caps if on piles.



The above cut shows side view of a Deck Bridge on steel piles. This railing is known as "Painted Post Rail," and is one of our best sellers. In every town where we have sold this style, they consider it a neat and tasty railing. We use two angles at each place, making 12 in the two sides.

When we use pile foundations, we notch the flanges of the piles near the top and cap them with a heavy angle,—one leg of angle resting on top, while the other passes down along flat side of the pile and is held there by a ¾ inch clip, which wraps pile and passes through notches in flanges, then through cap, and held firmly by nuts on clip. The bridge and joists are bolted to caps, making it impossible to be torn away by floods.

Please write us. LANE BRIDGE WORKS,

PAINTED POST, N.Y.

Figure 42. Patented Lane Bridge

Wilmington, Ohio, which was responsible for numerous metal truss bridges in the state:

> . . .Two men who were to have a great influence upon the future of Champion Bridge were employed about this time--Edward J. Rose and Cash L. Richardson. Somewhere around 1904 Edward J Rose was hired as a draftsman. A few years later he became a salesman, traveling mostly through Kentucky, Tennessee, Virginia and the Carolinas. The bridge salesman's job was not an easy one in those days. It involved long hours on dusty, dirty trains and poor accommodations. Since many of the early bridges were built before the road, he would have to make long trips on horseback or by foot in all kinds of weather to check out the site and take measurements for the bridge. In the Appalachian back country it was usually advisable to hire a local guide. The mountain people were cautious of strangers; thus, it could prove dangerous to go into the mountains alone. Once they found out about your business and that you meant them no harm, the outsider discovered them to be warm and friendly people.
>
> As years passed, the automobile gradually replaced the train as a means of transportation for the salesman. Roads in the mountains, even as late as the 1940s, were very poor by present-day standards. Many were mud roads with no gravel and some would make use of a stream bed as a section of the road. One had to be able to perform his own mechanical work and carry enough parts and tools to take care of the problems that often arose. . . .
>
> Cash L. Richardson came to Champion in 1905. That year Gil Smith, one of the erection foremen, was building a bridge in Hardin County, Kentucky, near Elizabethtown. It was the custom to send the foreman out on a job, sometimes with another man, but usually alone. He would hire and train what local labor he could find to erect the bridge. On this job, Smith hired a 16-year-old boy from Vine Grove, Kentucky, Cash L. Richardson, as a water boy and for odd jobs. After this bridge was finished, Richardson returned to the farm. His father, having failed in health, set Cash up in the tobacco business. A fire, accidentally started from ashes from his father's pipe, destroyed Richardson's first crop after it had been hung in the barn. Thus it was necessary for him to look for a job off the farm. He contacted Champion and was again employed on the erection crew. Learning quickly, he was soon promoted to erection foreman. By the time of his death in 1965, he held the record of erecting more bridges than any other man in the United States.

If the saleman's job was difficult, the erection crew's job was even worse in those days. Many of the bridges were in isolated areas and accommodations were hard to find. Usually the local people were glad to have the bridge and would take the men into their homes so that the new bridge could be built. Sometimes, though, they would have to build a shack or live in a tent when there were no nearby accommodations. Some accommodations were good and some were very poor. Cash Richardson told a story of an old eastern Kentucky hotel where during the night he was awakened by rats fighting in the bureau drawer and later was disturbed by one that had made a nest in the underside of the mattress. Vergil Kuhns, a long-time employee, tells of staying in another old, but clean, hotel. On arising he found himself and the bed completely covered with tiny red ants. "Guess they came out about that time every year!" was his comment. . . .

The steel and the tools would be shipped ahead by rail and hopefully would arrive in the nearest siding by the time the foreman reached the site. After hiring a crew (the foreman) would have to make arrangements to have the steel hauled to the site by local teamsters. Sometimes the only access was by water, and a number of Florida bridges were built entirely off of barges. Champion had a number of barges, boats, floating cranes and pile drivers in use in the Florida operations. Hauling the bridge to the site was particularly difficult in the mountains, where the roads were bad or non-existent. Six to eight mules with a wagon, hub deep in mud, would haul the bridge a piece at a time, sometimes for miles, to the bridge site. Sometimes the mountains were so steep that blocks and tackles had to be used to raise or lower the wagons. The foreman would have to deal locally for lumber, cement and other supplies. Footers had to be dug deep enought for solid footing. Scaffolding had to be built in the hole, with platforms each manned by a crew of shovelers so the dirt from the deepest part had to be moved several times before it reached the top. Sometimes they rigged up a block and tackle to remove the dirt. Water was a problem and hand pumps had to be used to keep it out. Later, this job was made easier by gasoline pumps. Stream gravel was used for the concrete but, where none could be found, it had to be broken from the rock with knapping hammers. In the early days, all concrete was mixed by hand on a large platform, but later gasoline mixers were used. After the abutments and piers were completed, scaffolding was built and the bridge was erected mainly by manpower with the aid of block and tackle or a crab. Steam hoists were used on the larger jobs. This was a particularly dangerous time since, until the bridge was swung, it was highly vulnerable to floods or debris and logs coming down stream. The bridge was so

designed that most of the riveting was done in the shop, as the field rivets had to be driven by hand. Imagine trying to drive a 3/4" rivet with a sledge hammer on the top chord of a 60-foot-high bridge in the winter time!

Even when things went well, the job was hard and life was difficult by modern standards. Winter erection, particularly in the mountains, was the worst. The erector had to fight the mud and the cold--there is no colder place than a bridge perched high over the stream catching the full blast of the winter winds coming down the valley. Bridgemen had to be tough and a hardy breed of man, though many, such as typified by Albert H. (Pappy) Simpson, were kind and gentle men. Generally, the local people were glad to have the new bridge and the better roads that would follow and so they were kind and helpful to the crew. Though they had few material possessions, they were willing to share what they had. The bridgemen of Champion grew to respect and admire them and had a great affection for the Appalachian Mountain people. . . .

By 1900, Champion Bridge had a number of foremen working on jobs throughout the eastern half of the country. Often when one job was completed, the tools were packed and shipped on to the next job and the foreman wouldn't get home for some time. Some of the bridges fabricated by Champion were erected by others and at times the shop would not be able to keep up with the fabrication demands. At these times, parts such as eyebars would be purchased from other companies. Steel prices had declined, but one still wonders how they were able to build a bridge for the prices they received. For example, the present Lynchburg high truss 100-foot by 16-foot bridge over the East Fork was contracted (Contract No. 345) July 27, 1900 for $1995 for the superstructure. Also Champion was awarded the contract (No. 1421) on December 7, 1908 for the present 74-foot by 14-foot modified Pratt low truss on Lazenby Road, Clinton County, Ohio. The cost was $995 for 24,500 lbs. of steel, at an erected cost of $407 per hundredweight or $81.40 per ton. This bridge across East Fork of Todd's Fork was built by Albert H. Simpson. Now erection alone costs $100 plus per ton and fabricated steel would run $340 per ton![2]

By the 1890s many engineers, including leaders such as

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2 Mairs, David H., A Century of Bridges, Wilmington, Ohio, 1972.

Waddell,[3] were campaigning for a complete overhaul of the bridge-building business. They favored a system in which contractors would bid on a design, complete with drawings and specifications, and the appointed contractor would be supervised by resident engineers and inspectors representing the client (essentially the system used today). In an historical perspective, the profession was returning to "bespoke tailoring" instead of "ready made" products. This change was more rapid for the private railroad companies and really did not become established for highway bridges until the formation of state highway departments.

Many bridge builders, accustomed to the old system, resisted the new method because of all the "red tape" and the meddling of site inspectors. However, the established method of selling catalogue bridges waned and passed from the scene after World War I. Rather than their own proprietary system, the new role for these bridge companies was to fabricate bridge components according to an engineer's design. The second factor in the passing of the catalogue iron truss bridge was the appearance, just after the turn of the century, of a new structural material: reinforced concrete. By the 1920s reinforced concrete had become the prefered material for short- and medium-span bridges. Steel truss and girder bridges were reserved for longer spans in excess of 80-100 feet.

Theme and Variations

Many of the patents for iron truss bridges were devised to

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[3] Waddell, J.A.L., Bridge Engineering, John Wiley & Sons, New York, 1916, pp. 36-44.

afford protection for a particular bridge company in the face of very stiff competition in an unregulated market. Amidst a plethora of patents there was an important development based upon the Pratt truss.

In proportioning the truss, the engineer must consider an optimum or economical design not only for the trusses but also for the deck system, since floor beams or stringers longer than about 25 feet result in an expensive deck system. The optimum configuration for a Pratt truss, with the diagonals at a 45-degree angle, limits the height of the truss to 25 feet and--even more important--limits the spans. A ratio of one-third the depth to span length represents a minimum proportion consistent with economy. Thus, the length of a Pratt truss was effectively limited to 250 feet.

The double-intersection Pratt truss, often called the Whipple or Whipple/Murphy truss, avoided this problem by running the diagonals over two panels. The diagonals could be maintained at the optimum of 40 to 45 degrees, with the panels--and hence the stringers--just over half the length of the horizontal projection of the diagonal. For spans of over 125 feet, the Whipple truss became a popular form during the second half of the 19th century, particularly, in the case of highway bridges, during the last two decades. In many ways the Whipple truss was the most elegant of all types employed during the 19th century (see Figure 43).

There were other solutions to the problem of stringer length and truss depth which resulted in the development of several distinct truss types. If the basic Pratt panel configuration is used for long spans, the floor stringers can be kept to a manageable length

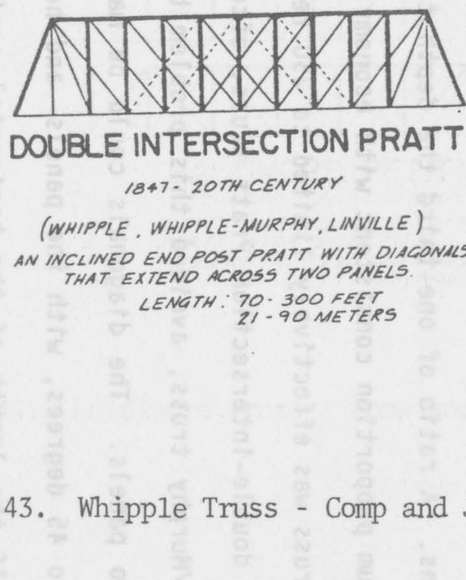

Figure 43. Whipple Truss - Comp and Jackson

by subdividing the panel (see Figure 44), resulting in the Baltimore truss.

The secret of the truss is, of course, its triangular configuration, in which members act in direct tension or compression, apart from secondary stresses. The truss can also be compared to a beam, in which the bending movement is sustained by the top and bottom chord and the vertical shearing stresses by the web members. From this analogy with a beam, it is well-known that the bending movement diminishes rapidly towards the end supports. It is, therefore, possible to reduce the size of the chords as they approach the end supports or--even more efficient--to decrease the height of the truss as it approaches the end. Depending on details, the result is the Pennsylvania (Petit), the Parker or the Camelback truss (see Figure 45).

Other truss systems which enjoyed brief periods of popularity include the McCullom, the Pegram, the Post, the Lenticular, *et al.* With few exceptions, the Pratt truss and its progeny became an American standard and represent the overwhelming number of truss bridges built from the 1880s until the Great Depression.

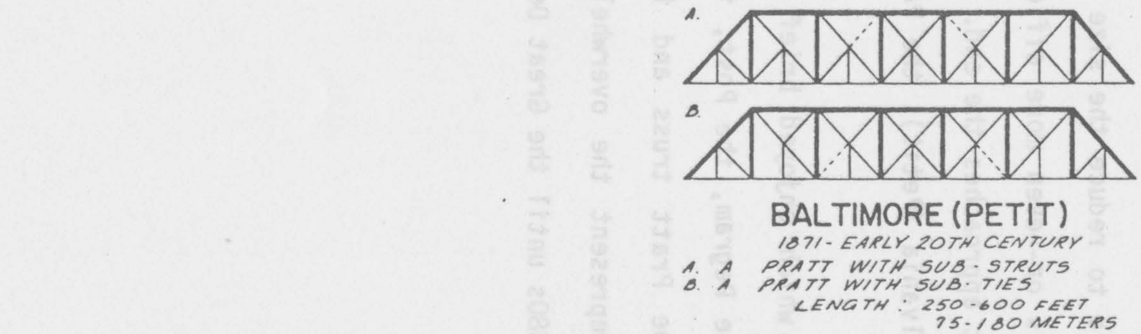

Figure 44. Baltimore Truss - Comp and Jackson

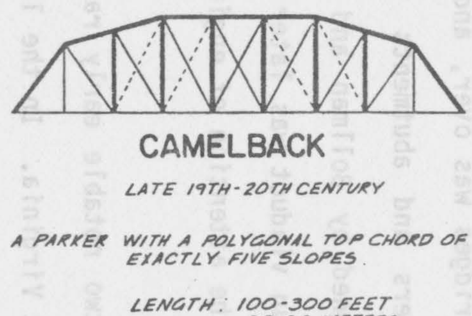

Figure 45. Camel Back Truss - Comp and Jackson

Stone, Brick and Plain Concrete

In 19th century Europe, stone was considered a "noble" building material with an ancient heritage of use in bridges and buildings. With an abundance of timber and a scarcity of skilled labor in the United States, stone was reserved for use in only the most important transportation systems. Fortunately, two of the most important transportation arteries--the National Road and the Baltimore and Ohio Railroad--passed through the Virginias.

By the time the B & O Railroad reached Harpers Ferry, the brief use of monumental stone bridges was over, and stone was used in a more humble mode for piers and abutments to support the great ironwork of bridges designed by Bollman and Fink. Intended as a stone viaduct, the Tray Run viaduct was later altered by Fink to an iron trestle, attracting the attention of engineers on both sides of the Atlantic.

There are, however, two notable early railway viaducts in the northern panhandle of West Virginia. In the 1850s, Charles Ellet of Wheeling Suspension Bridge fame was appointed as chief engineer for the Hempfield Railroad, a B & O branch line. It was during this time that a handsome stone viaduct was completed over Wheeling Creek. The viaduct, which can be clearly seen from Interstate 70 as it emerges from the tunnel under Wheeling Hill, continues to serve the B & O. Following the Civil War, the B & O penetrated into the midwest with crossings of the Ohio River at Parkersburg and Benwood. On the Ohio side, Benwood's main river spans are approached on a magnificent curved stone viaduct (Figure 30, page 83).

The National Road featured a number of stone bridges, including the famous "S" bridges. The "S" shape obviated the need for winding coursework in skewed masonry by crossing rivers at right angles and then curving the approaches to produce an "S" roadway alignment. The most important stone bridge on the National Road is across the Casselman River near Grantsville, Maryland, built in 1813. West Virginia's oldest bridge (1816) is on the National Road at Elm Grove. Although heavily disguised under layers of sprayed cement mortar and a comparatively recent ballustrade, this handsome three-span bridge is still in service.

A number of multi-span stone arch bridges were built before 1840 in the area between Hagerstown, Maryland and Martinsburg, West Virginia. Many of these are extant, including the famous bridge over Antietam Creek, the scene of the Civil War battle in 1862. Noted for its fine proportions, the sole representative of this group in West Virginia crosses Opequon Creek near Martinsburg (see Figure 46).

One of the most important stone arch bridges was constructed across Wheeling Creek in downtown Wheeling. This monumental bridge, which was completed in 1892 by Hoge & White, has a clear span of 159 feet. By the turn of the century, plain concrete had largely replaced cut stone for arch bridges and for bridge piers and abutments. Thus the Wheeling stone arch bridge marks the end of the stone structure era.

Although brick was a favorite building material for both road and railway bridges in England during the 19th century, it found

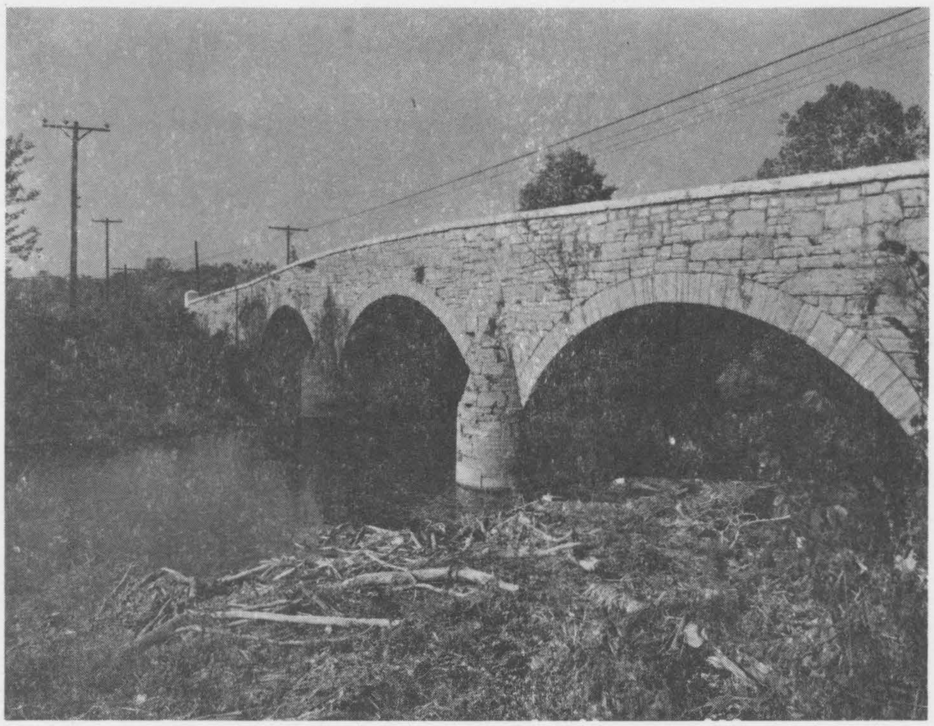

Figure 46. Van Metre Ford Bridge, 1832

limited application in America, especially in West Virginia. There are, however, several brick arch bridges in the northern panhandle, but none is noted for its age or important structural characteristics.

Enter Reinforced Concrete

Plain concrete was used as an inexpensive substitute for stone masonry. Not only was it cheaper but, because it could be molded in its plastic state into any shape that could be formed, it was a much more versatile building material. This artificial stone, as it was called, had the same inherent weakness in tension found in natural stone. Thus the provision of iron or steel reinforcing in an area of tensile stress overcame this weakness and, in so doing, created a new building mterial which has found worldwide acceptance. Indeed, it could be called the universal building material.

Cementitious components of calcium, in the form of lime or gypsum, have been used in masonry structure since ancient times. During the 19th century canal-building era, engineers sought a waterproof cement for locks and other hydraulic structures. A suitable cement was found by heating limestone in which a clay component was present. Because the resulting cement produced a waterproof mortar, it was called hydraulic cement. Although used extensively for masonry structures, hydraulic cement was little used for reinforced concrete.

Portland cement was patented by Joseph Aspdin in England in 1824, but its widespread use in the United States did not occur until the 1890s. This cement was quite superior to natural

hydraulic cement, since it was a careful blend of separate components and was fired at much a higher temperature, approaching incipient fusion. By the beginning of the 20th century it had largely replaced natural cement.

During this period the first pioneering efforts in the development of reinforced concrete were made. Like Joseph Paxton, who was responsible for the Crystal Palace in 1851, Joseph Monier of Paris was also a gardener. In 1861 he constructed flower pots, tubs and tanks of concrete reinforced with wire mesh. There had been earlier experiments with reinforced concrete, but Monier's work brought attention to the new material. At the same time, French engineer Coignet became the first to publish information on the principles of reinforced concrete and suggested its use for beams, arches and other structural applications.

By the 1880s a number of European patented systems, including those of Monier, Meland and Henebique, was available in America. The chief concern of British and American engineers at this time was the development of fireproof building systems. This certainly characterized the early work of Wilkinson in England and Hyatt in America. Hyatt correctly understood the use of reinforcement in beams and verified his ideas in a series of tests performed by Kirkaldy in London, with results published in 1877. Hyatt's work was well in advance of his time and his insights into the behavior of reinforced concrete were, in a sense, rediscovered more than a decade later. P.H. Jackson, an American engineer, is also credited with the use of reinforced concrete as early as 1877.

The most important early use of reinforced concrete in America is the work of English engineer E. L. Ransome in California in the 1880s and 1890s. Engineers like Ransome utilized reinforced concrete in new ways that freed the material from being used in imitation of masonry or timber beams. The first step was use of the material in monolithic structures in which the floor slabs, beams and columns were all cast without joints. The second major development began in America as early as 1902, when Norcross and Turner experimented with construction of flat slabs (slabs resting directly on columns, without the use of beams). In such floors the concrete was required to bend in two directions. The next step was construction of three-dimensional shells in reinforced concrete. With these developments, the full potential of reinforced concrete was realized.[1]

In 1894 Edwin Thatcher introduced the Melan system of reinforced concrete arch bridges and built the first reinforced concrete bridge of significant span in America.[2] During the next decade, numerous systems were developed using various patented reinforcing bars. The Melan system used large rolled steel members, resulting in what would now be called encased steel construction. Most of the other systems used more conventional deformed bars. It was hardly a time of orderly development, but, like the early development of the metal

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1 Condit, Carl W., <u>American Building Art</u>, Oxford University Press, New York, 1961. For information on the history of concrete structures, see pp. 151-218.

2 Tyrrell, Henry G., <u>History of Bridge Engineering</u>, Chicago, 1911, pp. 408-413.

truss, a period of intense competition.

Until the end of the 1920s, when the day of standardized catalogue bridges was waning and bridges were custom-designed by highway departments and built by bridge contractors, the Luten Bridge Company of York, Pennsylvania dominated the field of reinforced concrete bridges in the Middle Atlantic region. There were numerous local firms active in building concrete bridges during the period, but none rivalled the ubiquitous Luten Bridge Company in the number of bridges built.

In West Virginia and neighboring states, Frank Duff McEnteer deserves special recognition as a pioneer in the use of reinforced concrete for highway bridges. In 1911 McEnteer came to Clarksburg as superintendent of construction of the Palace Furniture Company's new building and embarked upon a career in the building of reinforced concrete structures. After completion of the building, he remained in Clarksburg, forming a partnership with P. M. Harrison, York Bridge Company's Clarksburg representative. In 1914 McEnteer was appointed superintendent of construction of the Fourth Street Bridge, designed by the Luten Bridge Company, and thus began his interest in reinforced concrete bridges. In the same year his partnership with P. M. Harrison incorporated as the Concrete Steel Bridge Company, with McEnteer as president and general manager.

The Concrete Steel Bridge Company prospered by specializing in reinforced concrete structures. The company built over 1,000 bridges in West Virginia, ranging from modest spans of 20 feet to major multi-span bridges characterized by bold design, superior workmanship and construction economy. Many of these bridges are

extant, bearing witness to the soundness of their construction. In addition to bridges, the company built numerous industrial buildings, many still in use today, using a reinforced concrete frame and flat slab floor system. The Concrete Steel Bridge Company continued to expand and by 1925 had branch offices in Pittsburgh and Harrisburg, Pennsylvania; Huntington, West Virginia and Knoxville, Tennessee and a subsidiary company in Florida. By the late 1920s the company had further diversified its interests and owned the Builders Supply Company of Clarksburg.

With operations in several states and a diversity of interests, the company's financial resources were hard pressed in the Depression years when unexpected difficulties were encountered during construction of the large Hyner bridge in Pennsylvania. In 1931 the Concrete Steel Bridge Company was liquidated.

Following dissolution of his company, McEnteer joined the West Virginia State Road Commission, serving as district engineer from 1932 to 1938 and directing the construction of many highway bridges as construction engineer for the northern district from 1938 to 1940.

In 1942 McEnteer joined the firm of Johnson, Piper and Drake as a project manager on a war contract in the Middle East. As Rommel advanced into Egypt, McEnteer was sent as assistant foreign manager to construct an army base near Tel Aviv. In April 1943 he was made chief engineer of the construction division of the U.S. armed forces in the Middle East. Stationed in Cairo, he supervised the construction of airports from Dakar, West Africa to Iran and the Persian Gulf.

Returning to Clarksburg after the war, McEnteer opened an office as a consulting structural engineer. The firm McEnteer headed until his death in 1957 specialized in the design of highway bridges and industrial buildings. Among these were the warehouse, shops and garage for the Hope Natural Gas Company in Clarksburg and the expressway through Clarksburg.

The work of the Concrete Steel Bridge Company from 1912 to 1931 was a reflection of McEnteer's philosophy, as he stated it in 1931:

> During this period our company built approximately 1,000 highway bridges, or . . . about 50 a year. It was my realized purpose to avoid larger single contracts and instead to perfect an organization utilizing 500 to 1,000 men operating in small crews over half a dozen states. This minimized risk, accomplished frequent turnovers and required an interesting business coordination. I directed a sales force that had to have a new job ready for each crew to move to as it finished the one it was on, purchasing that got to each job materials and equipment on time, estimates and cost keeping that intelligently interpreted widely different conditions, superintendents who were resourceful and could do good work without calling for home-office assistance. As long as these principles were adhered to, our work was, as a whole, a major highway operation and profitable. The backbone of our business was concrete highway bridges of from 50 to 100 feet.[3]

Since the early designs of the Luten Bridge Co., et al., were patented on the basis of reinforcement details and not on structural form, the appearance of early concrete bridges was similar regardless of the company of origin. As a result, photographs of McEnteer's work can also serve to illustrate the state of the art in concrete bridge design from 1913 to 1931 (see Figures 47, 48 and 49

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[3] McEnteer, Frank D., correspondence, McEnteer Collection, West Virginia Collection, West Virginia University, Morgantown.

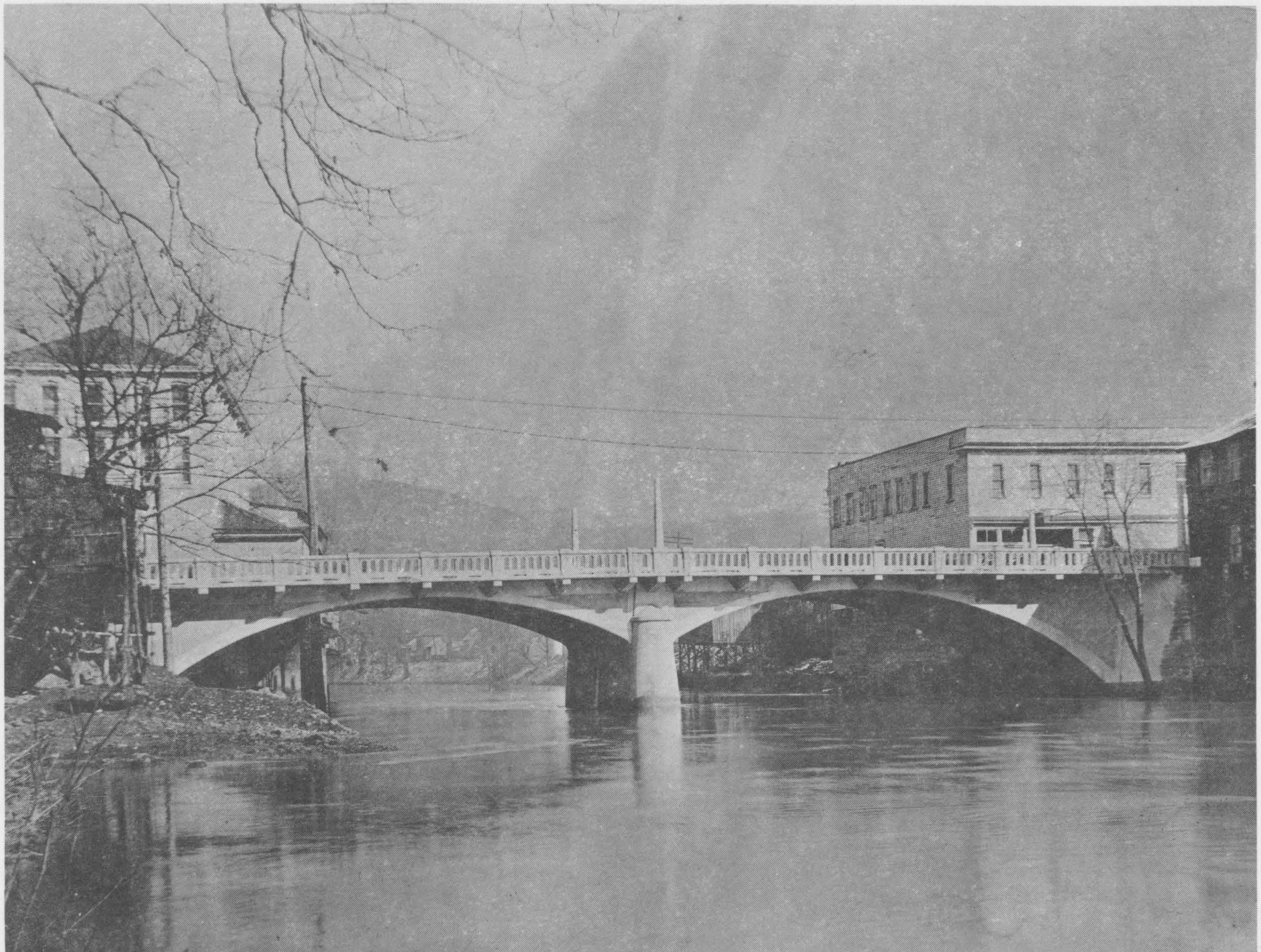

Figure 47. McEnteer's Weston Bridge - McEnteer Collection

Figure 48. McEnteer's Colwell Bridge - McEnteer Collection

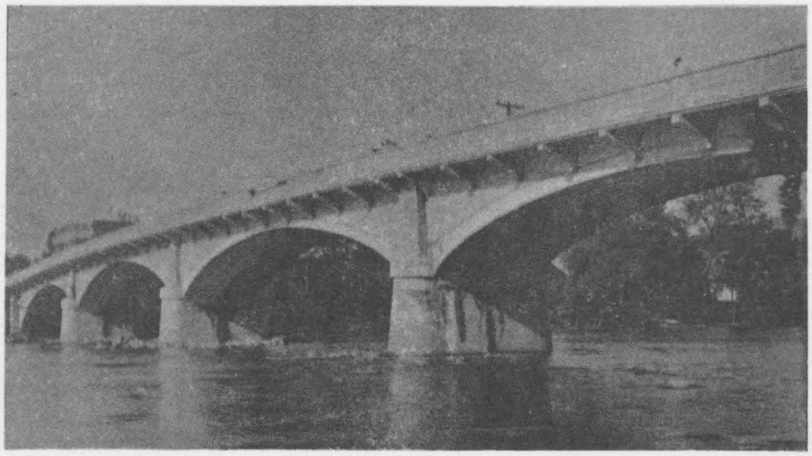

Figure 49. McEnteer's Alderson Bridge - McEnteer Collection

for examples of McEnteer's work -- from an early bridge for the York Bridge Co. at Blaker's Mill to larger and more sophisticated structures built later by the Concrete Steel Bridge Co.).

With the work of McEnteer and many similar firms across the nation, reinforced concrete became the preferred material for short- and medium-span bridges. Increasingly steel was reserved for long-span bridges where it could successfully compete with concrete. Not all of these early bridges were built from standardized designs. McEnteer was responsible for two large multi-span bridges early in his career, namely the Fourth Street Bridge in Clarksburg and the elegant four-span arch bridge at Alderson, West Virginia. These bridges were really preludes to the greatest reinforced concrete bridge in the state, the 1250-foot open spandrel bridge over the Monongahela River at Fairmont. Built in 1921 by the J.F. Casey Company, it features three continuous 272-foot concrete rib arches. Many concrete bridges were built in the decade following the completion of the Fairmont Bridge, but none approaches it in size or importance.

PART II: HISTORIC BRIDGE TAXONOMY AND EVALUATION

Introduction

Factors influencing the type, age and distribution of historic bridges in West Virginia include geography, settlement patterns, industry and such human factors as county courts and the sales acumen of bridge company representatives. West Virginia has a great diversity of these factors, with the result that each of the state's highway disticts has its own unique distribution of historic bridges. Thus this research project provides a good case study for other states and regions.

In dealing with a large number of historic structures such as bridges, a classification or taxonomy must be established for use in historical research and environmental impact studies and for development of a comprehensive historic preservation plan encompassing an entire state. The need is not just to classify historic structures but to develop an information retrieval system so that various kinds of information can be readily compiled. For example, in the case of bridges, one may wish to know how many Whipple (i.e., double-interection Pratt) trusses are extant in West Virginia. Equally likely, information may be required on all bridges built before 1850 or on all extant bridges built by a particular company. It should also be possible to retrieve information on a geographical basis by counties and highway districts.

Preservationists are reluctant to establish evaluation criteria

for historic structures, claiming that such criteria must be highly subjective and therefore of limited utility. In addition, many preservationists maintain that each structure is unique and therefore must be treated on an individual basis. These arguments are most appropriate for "high style" architecture such as Mount Vernon or Monticello, both in Virginia. This view would be applicable to the world's great bridges, such as the Eads Bridge of St. Louis, the Brooklyn Bridge and of course the Wheeling Suspension Bridge, which are unique.

The "uniqueness" argument for each historic structure is a position that is quite inappropriate when trying to establish an historical preservation plan for bridges on a statewide basis. In West Virginia alone there are more than 4000 bridges potentially eligible for the National Register of Historic Places on the basis of being at least 50 years old. An evaluation method is essential to the development of an historic preservation plan. A comprehensive evaluation procedure must include the historicity of the bridge and site, together with an evaluation of the aesthetic qualities of the bridge and its site. The decision to preserve a given bridge must also rest on the compatibility of the bridge with modern safety requirements for alignment and clearance. While age of an historic structure can be dealt with in a straightforward manner, evaluating its aesthetic qualities is necessarily a subjective matter, at least in part.

Perhaps the most difficult task is to develop and implement a plan which will preserve an appropriate number of historically

significant bridges. The implications of the term historic preservation do not mean that every old bridge in the state is to be restored to its original pristine conditon. Full restoration is reserved for those bridges possessing outstanding historical and/or aesthetic significance. In these cases, restoring the structure to its original condition is justified, providing the engineer's traditional concern for the safety of the traveling public is not compromised.

Full restoration is not justified for many historic bridges, but this does not mean an historic bridge must be replaced. It can be upgraded, in many cases, to meet modern highway requirements without compromising the historic fabric of the structure. Many bridges in West Virginia have been renovated very sensitively, with new decks, piers and/or members, without altering the essence of the original structure. Many of the bridges rated for preservation in this study fall into this category.

In those cases where an historic bridge must be removed in the wake of route relocation or because it is functionally obsolete, one of the mitigating factors in an environmental impact study would be to record the structure, with an appropriate set of measured drawings and photographs. In some cases, load testing of the bridge and/or its components before its removal can yield important historic information. The data on the bridge, including all the material in the West Virginia Department of Highways bridge file, should be transferred to an historic bridge archive maintained by the Department of Culture and History's Historic Preservation Unit.

Evaluation of Historic Bridges

The rating system developed for this project, shown in Table I (pages 143 through 145), has three broad categories, historicity, technological significance and environmental quality of the bridge and its site. Evolving through a series of trial methods and discussions with members of the Department of Culture and History and the Department of Highways, the system was further refined by evaluation of project details and approach as presented at a series of national, regional and state meetings.

Applied to bridges in West Virginia, the method appears sound for identifying those of such historical merit (ratings of 30 or above) that they are eligible for the National Register of Historic Places and also those of little historic or aesthetic merit (ratings less than 25), which can be replaced, if required. The method also provides a basis for judgement on level of preservation of bridges which have some historical or aesthetic qualities (ratings between 25 and 29) but do not merit individual listing on the National Register of Historic Places, although they may be included in an historic district or multiple-resource district nomination.

TABLE I
BRIDGE RATING SYSTEM

	POINTS	MAX. PTS.
I. HISTORICITY		
A. Development Period		
pioneering phase	6	6
early flourishing phase	4	
mature flourishing stage	2	
obsolescent phase	0	
B. Rarity in West Virginia		
sole survivor	6	6
rare	4	
unusual	2	
common	0	
C. Integrity		
in original condition	3	3
minor alterations	2	
substantially original condition	1	
major alterations	0	
D. Historicity of site		
national historical significance	3	3
state historical significance	2	
local historical significance	1	
not significant	0	
II. TECHNOLOGICAL SIGNIFICANCE		
A. Engineer/builder/company		
international leader	4	4
significant or unusual	3	

TABLE I
(continued)

prolific builder of conventional types	2	
contribution limited or unknown	1	
unknown	0	
B. Structural system and materials		
outstanding early example	4	4
significant early example	3	
unusual or novel	2	
excellent example of a widely used type	1	
typical	0	
C. Length and number of spans		
outstanding length and/or number of spans	3	3
noteworthy length and/or number of spans	2	
significant length and/or number of spans	1	
typical length and/or number of spans	0	
D. Architectural and/or engineering details		
outstanding	3	3
unusual or novel	2	
noteworthy example	1	
typical	0	
III. ENVIRONMENTAL QUALITY		
A. Aesthetic		
unusually fine proportions and details	4	4

TABLE I
(continued)

	noteworthy proportions and details	3	
	excellent example of widely used type	2	
	typical but in an attractive location	1	
	not significant	0	
B.	Route compatibility		
	exceeds alignment and geometric requirements	3	3
	acceptable alignment and geometric requirements	2	
	minor alterations only to meet geometric requirements	1	
	functionally obsolete	0	
C.	Integrity of site		
	site in original condition	2	2
	minor site alterations	1	
	site greatly altered	0	

Since this evaluation method is the crux of the historic preservation plan, it is appropriate to discuss details of it.

Under historicity, four items are considered in evaluating a bridge. The first concerns the development period. Recent work in the history of technology has found that certain technologies follow an S-shaped (i.e., logarithmic) development curve. The author has shown the validity of the hypothesis for suspension bridge development, with the implication that it is valid for bridges in general. If one subscribes to this hypothesis, the development

curve can be used as the basis for assigning values to dates for historic bridges.

The most signficant period is the early pioneering phase, in which new ideas are tested on actual bridges. In the early period, progress is slow and the actual curve rather flat. After the new system has been validated in practice, an initial flourishing phase occurs. During this period, there is a noticeable increase in the numbers built and an increase in certain parameters which measure this technological progress, the most significant in the case of bridges being span length. The rate of increase of development begins to slow in the mature phase but, in all likelihood, the number of units produced continues to increase. The particular technology finally reaches an obsolescent phase because it has been replaced by more advanced or more suitable technology. During this period, no significant progress is made and the number of units produced decreases rapidly. (The covered bridge is a good example. Beginning as the leading bridge type in antebellum America, superceded by the all-metal truss in the second half of the century, it was relegated to minor river crossings on secondary roads by 1900 and has not been built in West Virginia since 1918.)

The technological significance of a particular bridge can be discussed in various ways. The person or company responsible for a given bridge may add importance to the structure. Any bridges attributed to Ellet or Roebling, for example, would have international significance. There is also a place for engineers and

firms who were leaders in the field at the time a particular bridge was constructed. Similarly historically significant would be an obscure company producing an unusual bridge type, such as the Vulcan Road Machine Co. of Charles Town, West Virginia, which built the patented Lane Bridge, as they boasted, from new railroad iron.

Although certain bridge fabricating companies built bridges in immense numbers and thereby had a notable influence on the history of bridge engineering, the ubiquitous nature of their product militates against preserving individual examples. Such a firm was Canton Bridge Company of Canton, Ohio, builder of hundreds of metal truss bridges in West Virginia until the First World War. Examples of its conventional bridge types exist in every county.

Unlike buildings and other structures, bridges may be considered "pure" structures, since their sole purpose is to carry loads caused by traffic and their own weight. Thus any evaluation should emphasize the structural system, the materials employed and the significance of the length and number of spans. As indicated, span length for a given bridge type is an important parameter in assessing technological development. When coupled with the length of each span, the number of spans really measures the magnitude of the project.

Victorians were prone to add decorative features to manufactured goods, and bridges were no exception. While many deny the lack of integration and taste in these decorative arts, they represent our forebears' exuberance for fine ironwork. In addition to

architectural features, there may be noteworthy engineering details which should be reflected in any evaluation scheme.

Not only age but uniqueness must be considered in rating an historic bridge. The Wheeling Suspension Bridge, the Van Metre Ford Bridge and the Wichert Truss over the Potomac at Hancock are all sole suvivors of their type. Before contemplating restoration of an historic bridge, one should consider the integrity of the structure: Has it suffered major alterations during its life and is it feasible to "undo" these alterations? Would restoration to a bridge's original condition compromise its strength and hence the safety of the traveling public?

Included in the rating system is a factor to represent the historicity of the site, divided into four categories. The highest rating is for a site at which some historical event of national significance took place, such as the Wheeling Suspension Bridge on the National Road and Chenoweth's Philippi Bridge; the lowest is for a site that is not significant or has unknown historicity, like the vast majority of bridges surveyed in the study.

Another category of the rating method evaluates environmental quality, which amounts to approximately 25 percent. Under this category are three items. The first, aesthetics, is an important, albeit subjective, quality to evaluate. The second, route compatibility, must be evaluated in order to develop a meaningful preservation plan considering both the bridge's alignment with respect to the road and its clearance with regard to the passage of traffic. If extensive realignment or rebuilding of the bridge is

required for a particular site, in most cases it would be more prudent to restore a similar bridge, if one exists at another location.

The third item is integrity. If the site is so altered that it bears little resemblance to its original condition, even the most complete and accurate restoration of the bridge will fail to convey the ambiance of the original site and will make preservation questionable. This situation usually occurs in built-up urban areas. Historic bridges can, however, greatly enhance a townscape under the right circumstances, particularly in conjunction with an historic district.

All of West Virginia's state-owned bridges built in or before 1933 were evaluated using the system shown in Table I.

Research and Evaluation Procedures

Evaluation Procedures

In order to deal effectively and efficiently with the research aspects of a subject composed of more than 4000 individual structures, it was necessary to develop a systematic approach to gathering, classifying and evaluating the data. The research method involved a sequence of activities.

The first step was to obtain a computer printout of basic data on all of the bridges in the state highway system from Highway's Structure Inventory and Appraisal (SI&A) file. West Virginia has a statewide system, established in 1933, unlike the county and township systems in other states such as New Jersey. Thus the study, using centralized archives, examined nearly all of the bridges in the state. The only ones that "slipped through the net" were a limited number owned by municipalities or, in rare cases, by county courts. The printout was arranged by county, route number, milepost, general bridge type and date (a typical sheet is shown in Figure 1).

For this project, the county was considered as the basic reference unit. Thus for a given county a list of bridges built before 1933 was compiled from the computer sheets, including those bridges whose construction dates were unknown.

With this list as a guide, the file for each bridge was perused. If a bridge met the 1933 cutoff date, the official description, photograph and elevation sketch were photocopied from the SI&A file. In addition to information retrieval recording, each bridge was sited on small-scale county maps, including bridge

STRUCTURE LISTING AND YEAR-BUILT

COUNTY	ROUTE	MILEPOST	YEAR-BUILT	PHYSICAL VULNERABILITY
BROOKE	002/00	16.25	1946	STEEL GIRDER
BROOKE	002/00	16.29	1930	STEEL GIRDER
BROOKE	002/00	16.40	1930	STEEL GIRDER
BROOKE	067/00	.62	1978	STEEL GIRDER
BROOKE	067/00	1.22	1978	STEEL GIRDER
BROOKE	067/00	1.36	1978	STEEL GIRDER
BROOKE	067/00	2.51	1978	STEEL GIRDER
BROOKE	067/00	7.04	1917 *	SUSPENSION
BROOKE	067/00	7.60	1900	CANTILEVER AND TRUSS
BROOKE	067/00	8.52	1925	REINFORCED CONCRETE-MASSIVE ARCH
BROOKE	067/00	9.24	1901	CANTILEVER AND TRUSS
BROOKE	088/00	2.31	1970	STEEL GIRDER
BROOKE	002/00	.01	1904	SUSPENSION
BROOKE	001/00	.08	1971	STEEL GIRDER
BROOKE	001/00	3.38	1914	STEEL GIRDER
BROOKE	001/00	3.56	1904	STEEL GIRDER
BROOKE	001/03	.29	1912	REINFORCED CONCRETE-MASSIVE ARCH
BROOKE	001/07	1.72	1912	REINFORCED CONCRETE-MASSIVE ARCH
BROOKE	001/08	.03	1910 *	CANTILEVER AND TRUSS
BROOKE	002/02	.50	1948	STEEL GIRDER
BROOKE	002/02	.70	1970	STEEL GIRDER
BROOKE	007/00	.28	1960	CONCRETE GIRDER
BROOKE	007/00	1.06	1912	CANTILEVER AND TRUSS
BROOKE	007/00	1.10	1902	STEEL GIRDER

Figure 1

number, date, type and builder, if known. With this information, each bridge was field inspected, noting details needed for evaluation and, in most cases, taking black-and-white photographs and color slides. While field notes included comments on the condition of each bridge, they did not constitute an engineering evaluation of the bridge's strength or safety.

Using the research data and field inspection results, each bridge was then rated according to the system described previously, with each bridge listed in a separate column on a rating sheet (see Figure 2). For each county, data were tabulated by date, rating and bridge company, according to bridge type (see Figures 3A through C, 4A through C and 5A through G). In addition, each county bridge with a rating of 25 or more was listed separately by number, type, date and builder (see Figures 6A through F). This was done to aid in the development of an historic preservation plan (presented in a subsequent section), since these bridges possess sufficient historical and/or aesthetic qualities to merit special consideration. A histogram of bridge ratings was prepared for each district (see Figure 7 for a typical histogram). Data for all 55 West Virginia counties have been assembled in a separate volume.

Discussion of Results

The characteristics of historic bridges, as a group, vary greatly across the state and are influenced by a number of factors. One is immediately struck by the richness and diversity of bridges in West Virginia. Clearly, no simple explanation will suffice for

BRIDGE NUMBER HISTORICITY		21-1-4.18 1924 LUTEN 32'-8"	21-1-4.66 1924 LUTEN 60'-2"	21-1-6.49 1924 LUTEN 26'-7"	21-1-8.81 1924 LUTEN RIB ARCH 52'-0"	21-½-0.37 1923 CONC. ST. BR. CO. 23'-7"	21-5/7-0.61 1911 ARCH 24'-8"
development period	6	4	4	4	4	4	6
engr./builder/company	4	3	3	3	3	3	0
system & materials	4	2	3	2	2	2	4
length & no. spans	3	0	2	0	2	0	0
details	3	1	1	1	1	1	1
rarity	6	0	2	0	2	2	4
integrity	3	3	3	3	3	3	1
historcity of site	3	0	0	0	0	0	0
Sub Total	32	13	18	13	17	15	16
ENVIRONMENTAL QUALITY							
aesthetics	4	2	3	1	2	1	1
Rte compatibility	3	2	2	2	2	2	3
site integrity	2	2	2	2	2	2	2
Sub Total	9	6	7	5	6	5	6
GRAND TOTAL	41	19	25	18	23	20	22

HISTORIC BRIDGE PROJECT

LEWIS 21
District 7

Figure 2
153

District 6

COUNTY

DISTRICT

METAL TRUSS, GIRDER & BEAM BRIDGES

CATEGORY	TRUSS				GIRDER & BEAM			TOTALS
Dates	CAMEL BACK OR PARKER	BALTIMORE	PENNSYLVANIA (PETIT)	OTHER	PLATE GIRDER	STRINGER OR BEAM	OTHER	
pre 1890								
1890 - 1905	1-(1893) 1-(1897)		1-(1891)	1-Suspension (1904)	2-(1902) 1-(1904)	1-(1903)	1-Steel Truss on Stone (1902)	9
1906 - 1920	1-(1913)				1-(1914) 1-(1918)	1-(1908) 1-(1912)		5
1921 - 1933	1-(1932)				1-(1927)	1-(1930) 1-(1933)		4
Unknown					3-(unknown)	12-(unknown)		15
TOTALS	4		1	1	9	17	1	33 / 33

Figure 3A
Tabulation by Date

District 6

METAL TRUSS BRIDGES

COUNTY________

DISTRICT________

CATEGORY	WHIPPLE	PRATT			WARREN			OTHER	TOTALS
Dates		DECK	PONY	THROUGH	DECK	PONY	THROUGH		
pre 1890	2-(1882) 1-(1887)		1-(1886) 1-(1887) 1-(1888)		1-(1889)				7
1890-1905	1-(1894) 1-(1896)		1-(1905)	1-(1893) 1-(1895) 2-(1896) 2-(1897) 1-(1898) 1-(1901) 1-(1902) 1-(1904)		1-(1901) 1-(1903) 1-(1905)			16
1906-1920			1-(1906) 1-(1908) 1-(1909) 1-(1910) 4-(1912) 1-(1913) 1-(1919)	1-(1906) 1-(1909) 1-(1912) 1-(1915)		1-(1914)			15
1921-1933			1-(1931)	1-(1924)					2
Unknown			4-(unknown)	5-(unknown)					9
TOTALS	5		19	20	1	4			49 / 49

Figure 3B
Tabulation by Date

Distric. 6

CONCRETE & MASONRY BRIDGES

COUNTY ______

DISTRICT ______

CATEGORY	ARCHES				BEAMS & SLABS	OTHER	TOTAL
		CONCRETE			CONCRETE		
Dates	BRICK or STONE	OPEN SPANDREL	SOLID SPANDREL	BOWSTRING	R.C. BEAMS R.C. SLABS		
pre 1890							
1890 - 1905	1 - Stone Arch (1892)						1
1906 - 1920	1 - Brick Arch (1915) 1 - Stone Arch (1915)		1-(1912) 3-(1913) 6-(1914) 4-(1916) 4-(1917) 7-(1918) 2-(1919) 2-(1920)		1-slab-(1918) 1-beam-(1916) 1-beam-(1918)		34
1921 - 1933			1-(1921) 1-(1922) 3-(1923) 5-(1924) 1-(1925) 1-(1926) 2-(1927) 3-(1928) 1-(1929) 1-(1930) 1-(1932) 1-(1933)		1-sl.-(1922) 2-sl.-(1923) 2-sl.-(1924) 3-sl.-(1925) 3-sl.-(1926) 1-sl.-(1927) 2-sl.-(1928) 1-sl.-(1929) 1-sl.-1932 2-b.-(1926) 1-girder-(1926)		40
Unknown			12 - (unknown)		17 - slab - (unknown) 6 - beam - (unknown) 1 - girder - (unknown)		36
TOTALS	3		62		46		111 / 111

Figure 3C
Tabulation by Date

District 6

CONCRETE & MASONRY BRIDGES

COUNTY ______

DISTRICT ______

CATEGORY	ARCHES				BEAMS & SLABS	OTHER	TOTAL
		CONCRETE			CONCRETE		
Rating	BRICK or STONE	OPEN SPANDREL	SOLID SPANDREL	BOWSTRING	R.C. BEAMS R.C. SLABS		
31 - 35	1 - Stone Arch (1892)						1
26 - 30			2 - (1912) 2 - (1913) 3 - (1914) - (1918)				8
21 - 25	1-Stone Arch (1915)		1-(1913) 3-(1914) 2-(1916) 1-(1917) 5-(1918) -(1919) 1-(1920) 1-(1923) 1-(1926) 1-(1927) 1-(1930) 2-(unknown)		1- beam -(1916) 1 - beam - (1918) 1 - beam - (1926) 1 - girder - (1926)		25
16 - 20	1- Brick Arch (1915)		2-(1916) 2-(1917) 1-(1918) 4-(1924) 1-(1925) 1-(1928) 1-(1929) 3-(unknown)		1- slab - (1918) 1 - beam- (1926)		18
11 - 15			1-(1917) 1-(1920) 1-(1922) 1-(1923) 1-(1924) 1-(1927) 1-(1928) 1-(1932) 1-(1933) 6-(unknown)		11- sl. - (unknown) 1 - sl. - (1922) 1 - sl. - (1923) 1 - sl. - (1925) 2 - b. - (unknown) 1 - girder - (unknown)		32
6 - 10			1 - (1919) 1 - (1921)		4- b- (unknown) 5- s - (unknown) 1- s - (1923) 2 - s - (1924) 1 - s - (1925) 3 - s - (1926) 1 - s - (1927) 2 - s - (1928) 1 - s - (1929) 1 - s - (1932)		23
0 - 5					1 - slab - (1925) 1 - slab - (unknown)		2
TOTALS	3		60		48		111 / 111

Figure 4A
Tabulation by Ratings

District 6

METAL TRUSS BRIDGES

COUNTY________

DISTRICT________

CATEGORY	WHIPPLE	PRATT			WARREN			OTHER	TOTALS
Rating		DECK	PONY	THROUGH	DECK	PONY	THROUGH		
31 - 35			1 - (1887)	1 - (unknown)					2
26 - 30	2 - (1882) 1 - (1887) 1 - (1894)		1 - (1888) 1 - (1905) 1 - (1906) 2 - (1912) 2 - (unknown)	1 - (1893) 1 - (1896) 1 - (1897) 1 - (1898) 1 - (1901) 1 - (1902) 1 - (1904) 1 - (1909) 2 - (?)	1 - (1889)	1 - (1905)			23
21 - 25	1 - (1896)		1 - (1908) 1 - (1909) 1 - (unknown)	1 - (1895) 1 - (1912) 2 - (unknown)		1 - (1901)			9
16 - 20			1 - (1886) 1 - (1910) 2 - (1912) 1 - (1913)	1 - (1896) 1 - (1897)					7
11 - 15			1 - (1919) 1 - (1931) 1 - (unknown)	1 - (1915) 1 - (1924)		1 - (1903) 1 - (1914)			7
6 - 10				1 - (1906)					1
0 - 5									
TOTALS	5		19	20	1	4			49 / 49

Figure 4B
Tabulation by Ratings

District 6

COUNTY ________

DISTRICT ________

METAL TRUSS - GIRDER & BEAM BRIDGES

CATEGORY	TRUSS				GIRDER & BEAM			TOTALS
Rating	CAMEL BACK OR PARKER	BALTIMORE	PENNSYLVANIA (PETIT)	OTHER	PLATE GIRDER	STRINGER OR BEAM	OTHER	
31 - 35	1-(1893)						1- Steel Truss on Stone (1902)	2
26 - 30	1-(1897)		1-(1891)					2
21 - 25				1- Suspension (1904)	1-(1904)	1-(1903)		3
16 - 20	1-(1913) 1-(1932)				2-(1902) 1-(1914)	1-(1908) 1-(1912) 2-(unknown)		9
11 - 15					1-(1918) 1-(1927) 2-(unknown)	1-(1930) 1-(1933)		6
6 - 10					1-(unknown)	8-(unknown)		9
0-5						2-(unknown)		2
TOTALS	4		1	1	9	17	1	33 / 33

Figure 4C
Tabulation by Ratings

District 6

CONCRETE & MASONRY BRIDGES

COUNTY ______

DISTRICT ______

CATEGORY	ARCHES				BEAMS & SLABS		OTHER	TOTAL
		CONCRETE			CONCRETE			
Builders	BRICK or STONE	OPEN SPANDREL	SOLID SPANDREL	BOWSTRING	R.C. BEAMS	R.C. SLABS		
Baily & Baily			4-(1924)					4
Brooke Co. Court			1-(1921)			1-slab-(1918)		2
Concrete Steel Br. Co.			2-(1914) 1-(1923)					3
Duncan Const. Co.			1-(1918)					1
Ferris Br. Co.						1-slab-(1925)		1
Luten Br. Co.			1-(1912) 2-(1919) 1-(1929) 2-(1913) 1-(1920) 1-(?) 3-(1914) 2-(1923) 2-(1916) 1-(1925) 3-(1917) 2-(1927) 5-(1918) 2-(1928)					28
Ohio Co. Court			1-(1932)			1-slab-(1923)		2
TOTALS			38		3			41 / 41

Total of Pages 1 & 2 & 3 = 111

Figure 5A
Tabulation by Bridge Company

District 6

CONCRETE & MASONRY BRIDGES

COUNTY ______

DISTRICT ______

CATEGORY	ARCHES				BEAMS & SLABS	OTHER	TOTAL
		CONCRETE			CONCRETE		
Builders	BRICK or STONE	OPEN SPANDREL	SOLID SPANDREL	BOWSTRING	R.C. BEAMS R.C. SLABS		
Paige Carey Co	1-Stone Arch-(1892)						1
Pipes & Johnson					1-slab-(1922)		1
Pipes & Watson			1-(1918)		1-beam-(1918)		2
Prison Labor					1-slab-(1927)		1
Ralston & Robb					1-slab-(1925)		1
State Forces			1-(1924)				1
O. A. Queen			1-(1930)				1
TOTALS	1		3		4		8 / 8

Figure 5B
Tabulation by Bridge Company

District 6

CONCRETE & MASONRY BRIDGES

COUNTY ______

DISTRICT ______

CATEGORY		ARCHES			BEAMS & SLABS	OTHER	TOTAL
		CONCRETE			CONCRETE		
Builder	BRICK or STONE	OPEN SPANDREL	SOLID SPANDREL	BOWSTRING	R.C. BEAMS R.C. SLABS		
Tyler Co. Court					1 - slab - (unknown)		1
Venable Const. Co.					1 - beam - (1926)		1
Wetzel Co. Court			1 - (1916) 1 - (1922)				2
York Br. Co.			1 - (1913)				1
Unknown	1 - Stone Arch (1915) 1 - Brick Arch (1915)		1 - (1917) 1 - (1918) 1 - (1926) 1 - (1928) 1 - (1933) 5 - (unknown)		1 - sl. - (1923) 2 - sl. - (1924) 1 - sl - (1925) [illegible] - sl. - (1927) 2 - sl - (1928) 1 - sl. - (1929) 1 - sl. - (1932) 17 - sl. - (unknown) 1 - b. - (1916) 1 - b. - (1926) 4 - b. - (unknown) 1 - girder - (1926) 1 - girder - (unknown)		46
TOTALS	2		13		36		51 / 51

Figure 5C
Tabulation by Bridge Company

District 6

METAL TRUSS BRIDGES

COUNTY ______

DISTRICT ______

CATEGORY	WHIPPLE	PRATT			WARREN			OTHER	TOTALS
Builder		DECK	PONY	THROUGH	DECK	PONY	THROUGH		
American Br. Co				1-(1924)					1
Canton Br. Co.			1-(1906)	1-(1893) 1-(1898) 1-(1901) 1-(1904) 1-(1909) 1-(1912)					7
Columbia Br. Works	1-(1887)								1
E.C. Dodd			1-(1931)			1-(1914)			2
Farris Br. Co.				1-(1915)					1
King Iron Br. Co.			1-(1887)	1-(1896) 1-(1897)					3
Massillon Br. Co.			1-(1888)						1
TOTALS	1		4	10		1			16 / 16

Total of Pages 1 & 2 = 49

Figure 5D
Tabulation by Bridge Company

District 6

COUNTY________

DISTRICT________

METAL TRUSS BRIDGES

CATEGORY	WHIPPLE	PRATT			WARREN			OTHER	TOTALS
Builder		DECK	PONY	THROUGH	DECK	PONY	THROUGH		
Mt. Vernon Br. Co.				1-(1902)					1
Toledo Massillon Br. Co.			1-(1908)						1
Tyler Co. Court			1-(1909)						1
W.Va Br. Co.			1-(1905)			1-(1905)			2
Wrought Iron Br. Co.	2-(1882) 1-(1894) 1-(1896)		1-(1886)	1-(1895) 1-(1896) 1-(1897)					8
York Br. Co.			4-(1912) 1-(1913)						5
Unknown			1-(1910) 1-(1919) 4-(unknown)	1-(1906) 5-(unknown)	1-(1889)	1-(1901) 1-(1903)			15
TOTALS	4		15	10	1	3			33 / 33

Figure 5E
Tabulation by Bridge Company

District 6

METAL TRUSS GIRDER & BEAM BRIDGES

COUNTY ______

DISTRICT ______

CATEGORY	TRUSS				GIRDER & BEAM			TOTALS
Builder	CAMEL BACK OR PARKER	BALTIMORE	PENNSYLVANIA (PETIT)	OTHER	PLATE GIRDER	STRINGER OR BEAM	OTHER	
American Br. Co.							1 - Steel On Stone (1902)	1
B & O Railroad					1 - (1927)			1
Nelson & Buchanon						1 - (1903)		1
Keeley Br. Co.						1 - (1930)		1
Pennsylvania Railroad					1 - (1914)			1
Fort Pitt Br. Co.	1 - (1932)							1
Steubenville Br. Co.				1 - Suspension (1904)				1
TOTALS	1			1	2	2	1	7 / 7

Total of Pages 1 & 2 = 33

Figure 5F
Tabulation by Bridge Company

District 6

METAL TRUSS, GIRDER & BEAM BRIDGES

COUNTY

DISTRICT

CATEGORY	TRUSS				GIRDER & BEAM			TOTALS
Builder	CAMEL BACK OR PARKER	BALTIMORE	PENNSYLVANIA (PETIT)	OTHER	PLATE GIRDER	STRINGER OR BEAM	OTHER	
Wrought Iron Br. Co	1-(1893) 1-(1894)							2
York Br. Co.	1-(1913)							1
Unknown			1-(1891)		2-(1902) 1-(1904) 1-(1918) 3-Unknown	1-(1908) 1-(1912) 1-(1933) 2-Unknown		23
TOTALS	3		1		7	15		26 / 26

Figure 5G
Tabulation by Bridge Company

FORM MT-26
2-1-79

THE WEST VIRGINIA DEPARTMENT OF HIGHWAYS

STRUCTURES DIVISION

BY: DATE: CHECKED: DATE: ORGANIZATION:	Bridges, with Ratings of 25 or Over	BRIDGE NO. COUNTY Hancock #15 DISTRICT 6	SHEET OF

Bridge #	Type	Date	Builder
* 15 - 11/5 - 0.01	Concrete Arch	1912	Unknown

* - indicate a bridge with a rating of 50 or over

Figure 6A

FORM MT-26
2-1-79

THE WEST VIRGINIA DEPARTMENT OF HIGHWAYS

STRUCTURES DIVISION

BY: DATE: CHECKED: DATE: ORGANIZATION:	Bridges With Ratings of 25 or Over	BRIDGE NO. COUNTY Ohio #35 DISTRICT 6	SHEET OF

	Bridge #	Type	Date	Builder
*	35 - 250S - 0.57	Stone Arch	1892	Paige Carey Co.
	35 - 2 4.56	Warren Deck	1889	Unknown
	35 - 43 - 0.02	Pratt Pony	1888	Massillon Br. Co
*	35 - 40 - 0.00	Camelback	1893	Wrought Iron Br. Co.
	35 - 252 - 0.01	Pennsylvania Petit	1891	Unknown

* - indicates a bridge with a rating of 30 or over

Figure 6B

5

FORM MT-26
2-1-79

THE WEST VIRGINIA DEPARTMENT OF HIGHWAYS

STRUCTURES DIVISION

BY: DATE:	Bridges With	BRIDGE NO.	SHEET
CHECKED: DATE:	Ratings of 25 or Over	COUNTY Wetzel #52	
ORGANIZATION:		DISTRICT 6	OF

Bridge #	Type	Date	Builder
52-7/23-1.23	Pratt Pony	1912	York Br. Co.
52-20/1-0.12	Pratt Pony	1912	York Br. Co.
52-8-7.85	Pratt Through	1898	Canton Br. Co.
52-12-3.66	Pratt Through	1893	Canton Br. Co
52-250-5.45	Concrete Arch	1918	Luten Br. Co.
52 9-4.41	Concrete Arch	1914	Conc. Steel Br. Co.
52 84 7.20	Concrete Arch	1914	Luten Br. Co.
52-7/5-0.02	Concrete Arch	1913	York Br. Co.

Figure 6C

8

FORM MI-26
2-1-79

THE WEST VIRGINIA DEPARTMENT OF HIGHWAYS
STRUCTURES DIVISION

BY:	DATE:		BRIDGE NO.	SHEET
CHECKED:	DATE:	Bridges With Ratings of 25 or Over	COUNTY Marshall #21	
ORGANIZATION:			DISTRICT 6	OF

Bridge #	Type	Date	Builder
26 - 15 - 1.54	Whipple	1887	Columbia Br. Works
26 - 27 - 1.31	Whipple	1882	Wrought Iron Br. Co.
26 - 5 - 1.69	Whipple	1882	Wrought Iron Br. Co.
26 - 74 - 18.50	Whipple	1894	Unknown
26 - 74 - 16.80	Camelback	1892	Wrought Iron Br. Co

Figure 6D

FORM MT-26
2-1-79

THE WEST VIRGINIA DEPARTMENT OF HIGHWAYS

STRUCTURES DIVISION

BY: DATE: CHECKED: DATE: ORGANIZATION:	Bridges With Ratings of 25 or over	BRIDGE NO. COUNTY Brooke #5 DISTRICT 6	SHEET OF

	Bridge #	Type	Date	Builder
(5)	5-2-10.23	Cantilever Truss	1902	American Br. Co.
	5-32/3-1.73	Concrete Arch	1913	Luten Br. Co.
	5-1/7-1.72	Concrete Arch	1912	Luten Br. Co.
	5 32 2.15	Concrete Arch	1913	Luten Br. Co.
	5 32-2.26	Warren Pony	1905	W.Va. Br. Co.
	5 32-2.36	Pratt Pony	1905	W.Va. Br. Co
	5-67-7.60	Pratt Through	Unknown	Unknown

X indicates a bridge with a rating of 25 or over

Figure 6E

7

FORM MT-26
2-1-79

THE WEST VIRGINIA DEPARTMENT OF HIGHWAYS

STRUCTURES DIVISION

BY: DATE: CHECKED: DATE: ORGANIZATION:	Bridges With Ratings of 25 or Over	BRIDGE NO. COUNTY Tyler #48 DISTRICT 6	SHEET OF

Bridge #	Type	Date	Builder
48-14-1.73	Pratt Through	1896	King Br. Co.
48-62-4.05	Pratt Through	1897	King Br. Co
48-10/1-3.60	Pratt Through	1901	Canton Br. Co.
48-56/1-0.04	Pratt Through	1902	Mt. Vernon Br. Co.
48-60-1.55	Pratt Through	1904	Canton Br. Co.
48-11-0.45	Pratt Through	1909	Canton Br. Co.
48-10-1.55	Pratt Through	Unknown	Unknown
48-14/4-0.27	Pratt Through	Unknown	Unknown
48-7-10.27	Pratt Pony	1906	Canton Br. Co.
48-18/4-3.19	Pratt Pony	Unknown	Unknown
48-18/17-0.30	Pratt Pony	Unknown	Unknown
(*) 48-6-9.78	Pratt Pony	1887	King Iron Br. Co
48-50-0.45	Concrete Arch	1916	Unknown
48-24-0.78	Concrete Arch	1914	Unknown
48-18-4.45	Concrete Arch	1930	O. A. Queen
48-18-20.53	Concrete Beam	1926	Venable Const. Co.

16 (*) - indicates a bridge with a rating of 50 or over

Figure 6F

FORM MT-28
2-1-79

THE WEST VIRGINIA DEPARTMENT OF HIGHWAYS

STRUCTURES DIVISION

BY: DATE:	Histogram Of Bridge Ratings	BRIDGE NO.	SHEET
CHECKED: DATE:		COUNTY	
ORGANIZATION:		DISTRICT 6	OF

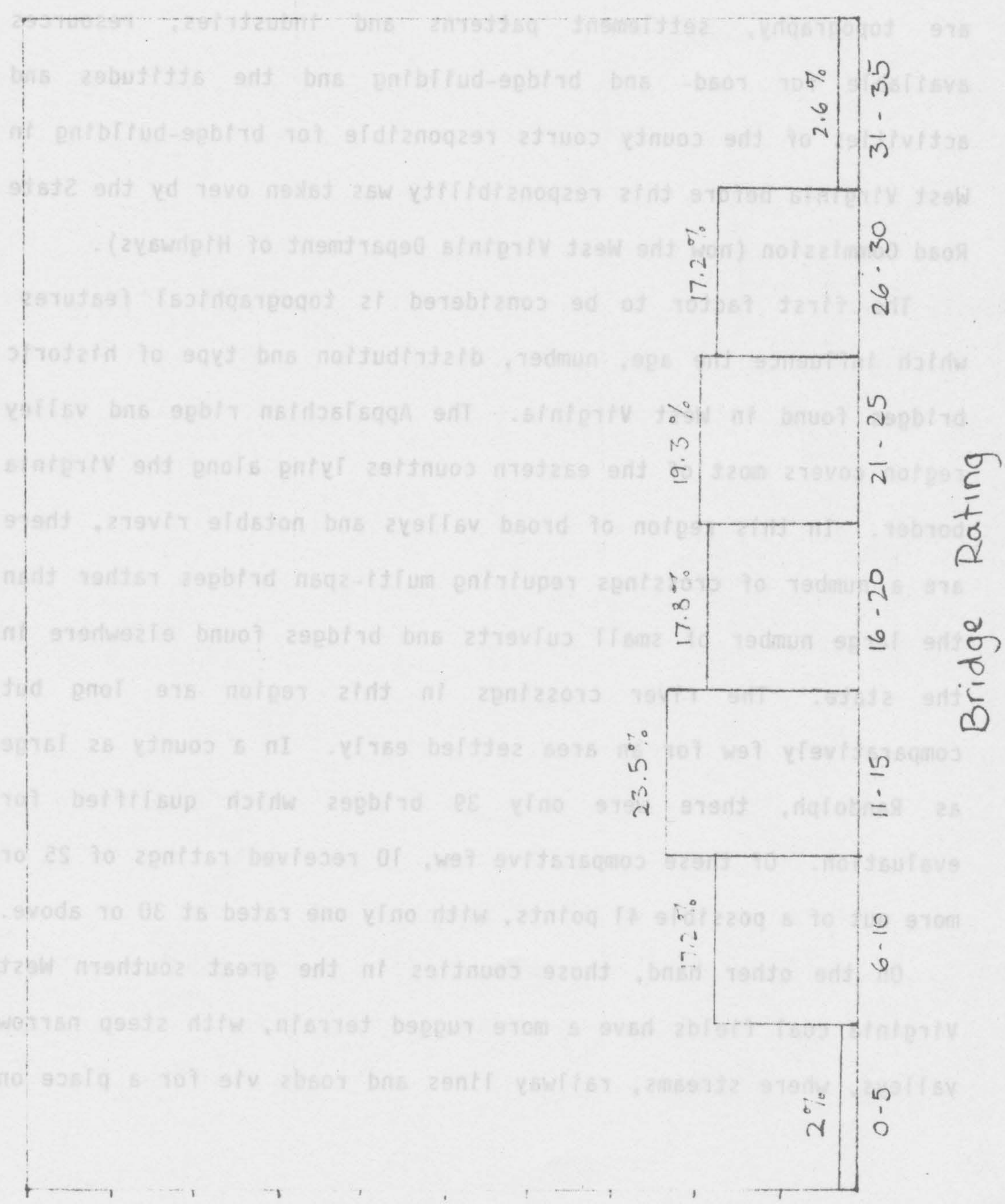

Figure 8
Typical Histogram

the types, numbers, age or distribution of this heritage of bridges, which represents a major public investment of time, money and skills, with roots in Virginia antedating the formation of the state.

Although no simple explanation is possible, this study has resulted in insights into these factors, the most important of which are topography, settlement patterns and industries, resources available for road- and bridge-building and the attitudes and activities of the county courts responsible for bridge-building in West Virginia before this responsibility was taken over by the State Road Commission (now the West Virginia Department of Highways).

The first factor to be considered is topographical features which influence the age, number, distribution and type of historic bridges found in West Virginia. The Appalachian ridge and valley region covers most of the eastern counties lying along the Virginia border. In this region of broad valleys and notable rivers, there are a number of crossings requiring multi-span bridges rather than the large number of small culverts and bridges found elsewhere in the state. The river crossings in this region are long but comparatively few for an area settled early. In a county as large as Randolph, there were only 39 bridges which qualified for evaluation. Of these comparative few, 10 received ratings of 25 or more out of a possible 41 points, with only one rated at 30 or above.

On the other hand, those counties in the great southern West Virginia coal fields have a more rugged terrain, with steep narrow valleys, where streams, railway lines and roads vie for a place on

the valley floor. The counties of Raleigh, Wyoming, McDowell and Mercer have 70 bridges listed in the study and nearly all are of comparatively short span. Thus 10.8 percent received ratings of 25 or more although only one in Wyoming County rated 30 or above.

In contrast, because the Ohio River is such a large barrier that ordinary "catalogue" bridges would not suffice, a number of very significant "bespoke" designed bridges have been built across it. The first was the famous Wheeling Suspension Bridge in 1849, followed by the railway bridge at Steubenville, designed by J.H. Linville and built in 1863-1864, and two Baltimore and Ohio Railroad bridges at Parkersburg and Benwood in the 1870s. Notable in recent years was the ill-fated Silver Bridge, built in the 1920s.

Not only were Ohio and Marshall counties settled early but the Northern Panhandle became a center for heavy industry. It is not surprising that a number of early iron bridges of considerable merit were erected in Marshall County across tributaries of the Ohio River, with Whipple (i.e., double-intersection Pratt) trusses representing the latest in bridge design at the time of construction. They remain a notable feature of the county.

In Ohio County, on the other hand, historic bridges are associated with the great National Road, which reached Wheeling before 1820. The oldest bridge in the state is a three-span stone arch over Wheeling Creek at Elm Grove, completed in 1816. The first bridge across a portion of the Ohio River was a covered bridge crossing the back channel of Wheeling Island and part of the

Wheeling and Belmont Bridge Company property, which included the famous suspension bridge. Built in 1836 and attributed to Lewis Wernwag, it was replaced in 1893 by a camelback Pratt truss with the most impressive architectural ironwork of any bridge in West Virginia.

County seat of Lewis County, Weston was the junction of the Staunton-Parkersburg and Weston and Gauley Bridge Turnpikes. Together with neighboring Harrison County, Lewis had an impressive number of covered bridges, several by Lemuel Chenoweth. There was little need for large, monumental bridges, since Weston never developed as an industrial center and the countryside, being in the middle of the Appalachian Plateau, is hilly, with many small streams. It is not surprising to learn that the county has 51 bridges which qualified for inclusion in the study, but only one which rated 30 points or more and only four with 25 or more. This clearly indicates that the many bridges built in the county in the first third of the 20th century were typically of short span and built at a comparatively late date.

These examples indicate that topography, settlement patterns and industry played a role in the construction of bridges in the Mountain State. The number of bridges depends on both the terrain and the density of population and hence the road network, but the type of bridge and the companies found represented in the county are strongly influenced by the human factor manifested in the county court. With bridges being sold on a catalogue basis by aggressive bridge salesmen, it is not surprising that certain companies were

favored over others by members of the county court. What else can explain three very early riveted Warren pony trusses built in 1890 in McDowell County by the Edge Moor Iron Company or the Whipple truss in Marshall County built by the Columbia Bridge Company? On occasion, for small jobs, county courts also favored obscure local fabricators or contractors in preference to well-established bridge companies. The Marion Machine and Foundry Company built several short-span Pratt pony trusses in the area around Fairmont, but is not featured elsewhere in the state.

The above examples clearly indicate that the study can easily provide historic bridge information for each county, which should be offered to county historical societies as a public service. Since the magnitude of this study precluded researching each bridge with some historic significance in the county court or other local archives, a thematic nomination for the National Register of Historic Places will necessitate preparation of a brief history of each bridge included in the nomination, in addition to the general history in this report, using local archival sources at either the county courthouse or the West Virginia and Regional History Collection in Morgantown. A computer printout to be developed by the Department of Highways for each bridge will provide the basic information, including the date and builder, which will make assessment much easier.

Historic Preservation Plan

A preservation plan is essential to save the very best of the state's historic bridges. Equally important is the establishment of a committee or council responsible for implementing the plan, for monitoring selected bridges on a continuous basis and for approving any repairs or alterations to these bridges.

The proposed plan is based on the bridge ratings obtained from the evaluation system developed. This system is useful in dividing the more than 4,000 bridges into categories ranging from most significant (ratings of 30 or more) to little historical significance (ratings less than 25). The following categories seem most appropriate for the preservation plan.

1. Landmark Structure

West Virginia's only landmark structure is the Wheeling Suspension Bridge (1849), identified as a national landmark, an American Society of Civil Engineers landmark and an international landmark. Clearly in a class by itself, it deserves special attention. Any repairs or restoration work should be done in accordance with the preservation plan developed for the bridge and with approval of the task force appointed by the Governor. Every effort should be made to have the bridge designated as a national monument under the National Park Service, which would be responsible for its maintenance and interpretation.

2. National Register Nominees

Those bridges judged to have the highest historical significance should be listed in the National Register of

Historic Places (a number of the state's historic bridges are already listed as individual sites). It is suggested that all eligible bridges (those with a rating of 30 or above) be submitted for listing by preparing a thematic nomination, an approach that has been used successfully for extant covered bridges. From this study 63 additional bridges would be eligible for the National Register, representing nearly two percent of the bridges evaluated as potentially eligible on the basis of being at least 50 years old.

Listing in the National Register of Historic Places will insure that these bridges receive appropriate environmental review if replacement or alteration using federal funds is contemplated. The Department of Highways will first analyze preservation in place by rehabilitation, building adjacent to existing, moving the existing bridge and, last of all, recordation before replacement is deemed necessary. Listing on the Register will also make the bridges eligible for certain federal rehabilitation funds.

Preservation can be related effectively to the state's emphasis on tourism, since there is considerable public interest in historic bridges, particularly covered bridges. In order to make these historic bridges known to the public, they will have to be featured in promotional literature. Even more important, guides are needed to direct the public to the bridges. It is therefore recommended that bridges listed in the National Register be designated with a specially designed logo which

would include the bridge's date and type. The attractive yet simple plaques would then be listed in a guidebook so that interested visitors could learn of their location and something of their historical significance. Guidebooks could be prepared for each of the six highway districts, distributed at state parks and the Cultural Center and sold at bookstores across the state.

The first step in preservation is nomination to the National Register. To facilitate preparation of nominations, Part I of this report can be used as the narrative. Those bridges receiving a rating of 30 or above would be listed in a thematic nomination for the National Register of Historic Places. Those bridges with a rating of 30 or more are listed separately in Appendix C.

3. Structures of Local Importance

From this initial survey, there are 286 bridges with ratings between 25 and 29 of some historic importance which do not merit inclusion in the National Register, but are nevertheless part of the Mountain State's rich heritage. Bridges in this category may be included in an historic district or be nominated as a local landmark by one of the state's landmark commissions. Since the majority of these bridges are on secondary roads with limited traffic, efforts will be made to preserve and restore them, rather than indiscriminately replacing them.

4. Others

The vast majority of the more than 4,000 bridges studied was judged to have historical and/or architectural significance insufficient to merit special consideration for preservation (ratings less than 25).

To avoid mitigation studies for these bridges on a case-by-case basis, it is important that the proposed preservation plan be adopted at the state level and endorsed by appropriate federal agencies responsible for compliance with Section 106 of the National Historic Preservation Act and Section 4(f) of the Department of Transportation Act of 1966.

Proposed Council on Historic Bridges

If the proposed preservation plan is to be approved and implemented, a special interdepartmental group will need to be established to represent both the Department of Highways and the Historic Preservation Unit of the Department of Culture and History. It is recommended that a council on historic bridges be established, through executive order or by an act of the legislature, with responsibility for preservation of historic bridges in West Virginia. The council's responsibilities would include, but not be limited to:

1. Implementing the proposed preservation plan to meet state preservation goals and federal 106 and 4(f) criteria so preservation decisions are no longer made on a case-by-case basis
2. Continuous updating of the inventory of old bridges established in the study

3. Recording, through drawings, photographs and written histories, those bridges which have some historical importance but do not merit listing in the National Register of Historic Places, especially those threatened with demolition
4. Establishing an archive of historic bridges for use in preservation work and interpretation to the public and by historians interested in technology and the history of West Virginia
5. Reviewing and commenting on maintenance and restoration/rehabilitation plans for all bridges designated for preservation (in the case of bridges listed in the National Register of Historic Places, no work which would alter the historic fabric of such bridges will be undertaken without the State Historic Preservation Officer's review of plans and specifications)
6. Providing professional services and other resources at its disposal to assist in the development and implementation of preservation work concerned with transportation, including services to municipalities on a consulting basis, with fees where appropriate
7. Assisting in obtaining federal, state and private grants for the preservation of historic bridges in West Virginia to supplement ordinary funds available to the West Virginia Department of Highways, recognizing that bridges on the state highway system are the responsibility of the Department of Highways or, in a few cases, the Department of Natural Resources or other governmental departments

8. Historic interpretation of West Virginia's rich heritage of bridges to the public through publications, site interpretation, television and other appropriate means.

As determined through discussions with the commissioners of Highways and Culture and History, the membership of the council would consist of:

1. Department of Highways Employees

   a. The Commissioner of Highways, _ex officio_, or his appointee (structures)

   b. Environmental Affairs Officer, _ex officio_

   c. Representative of the Bridge Maintenance Section

2. Department of Culture and History Employees

   a. The Commissioner of Culture and History, _ex officio_, or his appointee

   b. The State Historic Preservation Officer, _ex officio_

   c. Representative from Archives and History

3. Department of Natural Resources Employees

   a. The Director of Natural Resouces, _ex officio_, or his appointee

4. Gubernatorial Appointments

   a. A professional engineer or architect with experience in historic preservation

   b. A representative of the state's historical societies

   c. A representative of the Preservation Alliance of West Virginia, Inc.

   d. At-large member.

Members of the council will serve without compensation, but expenses to attend meetings and involvement in other authorized activities will be paid to the members.

The council will elect its own officers, establish meeting protocol and determine its own list of priorities in order to carry out its responsibilities in the most expeditious manner.

APPENDIX A: BIBLIOGRAPHY

Album of Designs, Phoenix Bridge Company, Philadelphia, 1888, 1895.

American Bridge Company of New York, The American Bridge Company, New York, 1908.

Backert, A. O., editor, The A. B. C. of Iron and Steel, 1915.

Book of Designs of Wrought Iron Bridges Built by the Wrought Iron Bridge Company, Job Abbott, Canton, Ohio, 1874.

"Bridge Superstructure," Transactions of the American Society of Civil Engineers, 1878, No. 7, pp. 339-49.

Brock, F. B., "Truss Bridges," Engineering News, 1882, No. 9, p. 371, 1883, No. 10, p. 5.

Burr, William H., The Stresses in Bridge and Roof Trusses, Arched Ribs and Suspension Bridges (5th edition), John Wiley and Sons, New York, 1889.

Butler, Joseph G., Jr., Fifty Years of Iron and Steel, Joseph G. Butler, Jr., Cleveland, 1919.

Catalogue, King Iron Bridge and Manufacturing Company, Cleveland, 1884.

(Catalogue), American Bridge Company, New York, 1872.

Clarke, Thomas G., "American Iron Bridges," Scientific American, Supplement No. 32, August 5, 1876.

Condit, Carl W., American Building, University of Chicago Press, Chicago, 1968.

Cooper, Theodore, "American Railroad Bridges," Transactions of the American Society of Civil Engineers, July to December 1889, No. 21, pp. 1-58.

Designs, King Iron Bridge and Manufacturing Company, Cleveland, (ca. 1875).

Dowling, Charles Hutton, Iron Work: Practical Formulae and General Rules for Finding the Strain and Breaking Weight of Wrought Iron Bridges, with Sundry Useful Tables, John Weale, London, 1866.

Drop-ends (company periodical), Virginia Bridge and Iron Company, Roanoke, Virginia, (ca. 1920).

Duggan, George, Specimens of Steel, Iron and Wood Bridges, Viaducts, Tunnels and Culverts of U. S. Railroads, New York, 1850.

Edwards, Llewellyn Nathaniel, A Record of History and Evolution of Early American Bridges, University Press, Orono, Maine, 1959.

Ferris, Herbert W., Historical Record Dimensions and Properties, Rolled Shapes, Steel and Wrought Iron Beams and Columns, American Institute of Steel Construction, 1953.

Ferris, H. W., editor, Iron and Steel Beams, 1873-1952, AISC, The Institute, New York, 1953.

Greiner, John Edwin, General Specifications for Bridges, 1911.

Haupt, Herman, General Theory of Bridge Construction, D. Appleton and Company, New York, 1851.

Henrici, Olaws M. F. E., Skeleton Structures, Especially in Their Application to the Building of Steel and Iron Bridges, New York, 1867.

Historical Sketch of the Development of American Bridge Specifications, Committee on Iron and Steel Structures, undated.

Hopkins, Henry J., A Span of Bridges, Praeger Publishers, Inc., New York, 1970.

Index of Patents Issued from 1790-1873, pp. 148-153 (bridge patents only).

Jacoby, Henry S., "Recent Progress in American Bridge Construction," Scientific American, Supplement 19, July 1902.

Ketchum, Milo S., The Design of Highway Bridges and the Calculation of Stresses in Bridge Trusses, Engineering News Publishing Co., New York, 1909.

Lane, D. F., Lane Bridge Works, Manufacturers of Lane, Pratt, Baltimore and Riveted Truss Bridges, also deck bridges, steel arches, sluice pipes and structural work, Painted Post, New York, 1901.

Laurson, Philip G., "The Development of Bridge Construction," Historical Papers of the Session on Civil Engineering and on Engineering Drawing and Descriptive Geometry, Bulletin 15, Lancaster Press, Inc., Lancaster, Pennsylvania, 1931, pp. 11-31.

Lesley, Jr., Iron Manufacturing Guide, J. Wiley, New York, 1866.

Lilly, George W., The Painting of Steel Bridges and Viaducts, unpublished, udated.

Miars, David H., A Century of Bridges: The History of the Champion Bridge Company and the Development of Industrial Manufacturing in Wilmington, Ohio, Wilmington, Ohio, 1972.

"Presidents Annual Report," 1912, 1913, 1922, Virginia Bridge and Iron Company, Roanoke, Virginia, 1912, 1913, 1922.

Purdon, C. D., Early Truss Bridges of Wood and Iron, Railroad Spans of the Eighties Marked by Many Peculiarities.

Rare Virginia Pamphlets, vol. 153, Illustrated Brochure of Major Projects of Virginia Bridge--mostly Major Railroad Bridges; Offices or Plants Listed at Roanoke, Atlanta, Memphis, New Orleans, Charlotte, Birmingham.

Ringwalt, John L., Development of Transportation Systems in the United States, J. L. Ringwalt, Philadelphia, 1888.

Schneider, Charles C., "The Evolution of the Practice of American Bridge Building," Transactions of the American Society of Civil Engineers, June 1905, pp. 213-234.

Skinner, F. W., Types and Details of Bridge Construction, McGraw Publishing Company, New York, 1904-1908.

Smith, C. Shaler, A Comparative Analysis of the Fink, Murphy, Bollman and Triangular Trusses, New York, 1865.

Swank, James M., History of the Manufacture of Iron. . . in the United States. . . to 1891, American Iron and Steel Assoc., Philadelphia, 1892.

Thatcher, Edwin, Bridge and Concrete Steel Construction, 1902, reprinted from Transactions of the Association of Civil Engineers of Cornell University, Vol. 10, 1902.

Tyrell, Henry Grattan, History of Bridge Engineering, G. B. Williams Company, Chicago, 1911.

Waddell, J. A. L., Bridge Engineering, John Wiley and Sons, Inc., New York, 1916.

Waddell, J. A. L., The Designing of Ordinary Iron Highway Bridges, John Wiley and Sons, New York, 1891 (5th edition, 1916).

Watson, Wilbur Jay, Bridge Architecture, J. H. Jansen, Cleveland, 1927.

Watson, Wilbur Jay, General Specifications for Concrete Bridges, 1908.

APPENDIX B

BRIDGE FABRICATORS AND/OR DESIGNERS

American Bridge Company
Ambridge, Pennsylvania

Atlantic Bridge Company

Atlantic-Bitulithic Company
Atlanta, Georgia

Bellefontaine Bridge Company
(Bellefontaine Bridge and Iron Company)
Bellefontaine, Ohio

Brackett Bridge Company
Cincinnati, Ohio

Bristol Steel and Iron Works
Bristol, Tennessee

Buckeye Bridge Company
Toledo, Ohio

Canton Bridge Company
Canton, Ohio

Champion Bridge Company
Wilmington, Ohio

Columbia Bridge Works
(Columbia Bridge Co.)
Dayton, Ohio

Concrete Steel Bridge Company
Clarksburg, West Virginia

Edgemoor Bridge Works
(Edgemoor Iron Company)
Wilmington, Deleware

Fairmont Machine Works
Fairmont, West Virginia

Fairmont Mining and Machine Company
(Fairmont Mining Machinery)
Fairmont, West Virginia

Farris Bridge Company
Pittsburgh, Pennsylvania

Ferris Bridge Company

Fort Pitt Bridge Company
Canonsburg, Pennsylvania

Fort Pitt Bridge Works

Groton Bridge and Manufacturing
 Company
Groton, New York

Helmick Foundry and Machine Company

Independent Bridge Company
Newville Island, Pennsylvania

King Iron and Bridge Works
 (King Bridge Company)
Cleveland, Ohio

Lomas Forge and Bridge Company

Luten Bridge Company
York, Pennsylvania

McClintic-Marshall
Bethlehem, Pennsylvania

Marion Machine Works
Palatine (Fairmont), West Virginia

Massillon Bridge Company
Massillon, Ohio
Toledo, Ohio

Merydith Bridge Company

Milwaukee Bridge Company
Milwaukee, Wisconsin

Mount Vernon Bridge Company
 (Mount Vernon Bridge Works)
Mount Vernon, Ohio

Nelson and Buchanon Company
 (Nelson and Buchanon Company)

Oregonia Bridge Company
Lebanon, Ohio

Owego Bridge Company
Owego, New York

Pan American Bridge Company

Penn Bridge Company
Beaver, Pennsylvania

Pennsylvania Steel Company
Steelton, Pennsylvania

Pittsburgh Bridge Company
Pittsburgh, Pennsylvania

Pittsburgh-Des Moines Steel Company

Roanoke Bridge and Iron Company
(Roanoke Iron and Bridge Company)
Roanoke, Virginia

Steubenville Bridge Company
Steubenville, Ohio

Toledo Massillon Bridge Company
(Toledo and Massillon Bridge Company)
Massillon, Ohio

Vincennes Bridge Company
Vincennes, Indiana

Virginia Bridge Company

Virginia Bridge and Iron Company
Roanoke, Virginia

Vulcan Road Machine Company
Charles Town, West Virginia

West Virginia Bridge and Construction Co.
Charleston, West Virginia

West Virginia Bridge Company
(West Virginia Bridge Works)
Wheeling, West Virginia

Wheeling Steel Corporation
Wheeling, West Virginia

Wheeling Structural Steel Company
Wheeling, West Virginia

Wrought Iron Bridge Company
Canton, Ohio

York Bridge Company
York, Pennsylvania

Youngstown Steel Bridge Company
(Youngstown Bridge Company)
Youngstown, Ohio

BRIDGE BUILDERS AND CONTRACTORS

Atkinson and Dolan
Baily and Baily
Beardslee and Melrose
Beeson and Helmick
Bishop, Robinson and Darnell
B. L. Black, Inc.
L. M. Boon
Boso and Ritchie
Braham and Yeater
R. W. Brown
J. G. Buzzard
J. (John) F. Casey
Nelson H. Clark
Clark and Lewis Company
George R. Clarke
R. D. Clems
A. N. Clower
E. P. Cokely
Cokely and Cooper Construction
Conley, Garrison and Douglas
Corns-Thomas Engineering Co.
Corns-Thomas Company
Davis and Reynolds
Davis and Rollyson
Dewey Brothers
C. C. Dodd
E. C. Dodd
Duncan Bridge Company
Duncan Construction Company
Echols Bros. Inc.
Garrison and Douglas
R. Giavani
Gilbert Construction Co.
J. E. Greiner and Company
Tom Groves
Highley Construction Co.
Merydith Construction Co.
Miam and Dodd
Floyd Michael
E. R. Mills
Minns and Dodd
Monty Brothers
Nelson and Copely
Nelson and Merydith
Paige Carey Company

A. B. Peraldo and Son
Pipes and Johnson
Pipes and Watson
Pocahontas Construction Co.
Polino Construction
Price Construction Co.
O. A. Queen
Ralston and Robb
J. T. Reaves and O. A. Wilson
H. F. Ringeling
Salem Concrete Company
N. G. Scott
Shaid Construction Co.
Spenser Construction Co.
Standard Engineering Cons.
Starcher and Angile
Edwin Starcher
A. A. Stollings
Thomas Company
A. T. Thompson
Thompson and Adkins
Tobin and Stover
Townsend and Minghini
Tully Construction Co.
Oscar Vecellio (Vecello)
Venable Construction Co.
S. T. Walker and Company
West Penn Public Service
West Virginia Courtney Co.
Wetzel Engineering Co.
Phil Williams
Withrow McClintic
S. Yon and Company

BRIDGE CONTRACTORS AND POSSIBLE FABRICATORS

Brookville Bridge Co.
Castor Bridge Company
Concrete and Iron Bridge Co.
Huntington and Ohio Bridge Co.
Huntington Concrete Co.
Keely Bridge Company
Ohio River Bridge and Ferry Co.

RAILROAD COMPANIES

Baltimore and Ohio Railroad
C. & O. Railroad
Monongahela Railroad Co.
Norfolk and Western Railroad
(N. & W. Railway Company)
Pennsylvania Railroad
Western Maryland Railroad

STATE AND LOCAL GOVERNMENT AGENCIES

INVOLVED IN BRIDGE BUILDING

Barbour County Court

Braxton County Court

Brooke County Court

Calhoun County Court

Lewis County Court

Mineral County Court

Ohio County Court

Pleasants County Court

Prison Labor

Randolph County Court

Ritchie County Court

Roane County Court

Tyler County Court

Upshur County Court

Webster County Court

West Virginia State Forces

Wetzel County Court

Wirt County Court

Wood County Court

APPENDIX C
NATIONAL REGISTER NOMINEES

DISTRICT ONE

NO./ COUNTY	COUNTY	BRIDGE #	TYPE	DATE	BUILDER
0	Boone	None			
0	Braxton	None			
0	Calhoun	None			
0	Clay	None			
1	Gilmer	11-40-7.26	Baltimore	1897	Canton Br. Co.
1	Jackson	*18-33/3-1.84	Pratt Through	1893	Wrought Iron Br. Co.
4	Kanawha	20-61SPUR-0.06	Pennsylvania (Cantilever)	1928-29	J.E. Greiner and Co.
		20-21/7-2.53	Pratt Through	1898	Groton Bridge Co.
		20-1/3-0.78	Pratt Through	1890	Wrought Iron Bridge Company
		*20-47-2.99	Pennsylvania (Petit) Truss	1913	Owego Bridge Co.
0	Putnam	None			
4	Roane	44-32-0.22	Pratt Through	1898	Castor Br. Co.
		44-13-7.41	Pratt Through	1909	Canton Br. Co.
		44-36-27.82	Concrete Arch	1912	Luten Br. Co.
		44-119-7.49	Concrete Arch	1907	Luten Br. Co.

DISTRICT TWO

NO./ COUNTY	COUNTY	BRIDGE #	TYPE	DATE	BUILDER
1	Cabell	6-31/6-0.48	Pratt Through	1882	Wrought Iron Br. Co.

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*Previously nominated or determined eligible for the National Register.

NO./ COUNTY	COUNTY	BRIDGE #	TYPE	DATE	BUILDER
0	Lincoln	None			
0	Logan	None			
1	Mason	27-2-20.54	Cantilever	1931	Holmes Const. Co.
1	Mingo	30-65/3-0.02	Bowstring Arch	1926	Luten Brige Co.
2	Wayne	50-60/4-0.54	Concrete Arch	1915	Luten Bridge Co.
		50-52/38-0.01	Pratt Through	ca.1885	Unknown

DISTRICT THREE

NO./ COUNTY	COUNTY	BRIDGE #	TYPE	DATE	BUILDER
2	Fayette	10-82-4.61	Pennsylvania (Cantilever)	1889	Unknown
		10-13-0.01	Camelback	1928	McClintic & Marshall
5	Greenbrier	13-02-0.01	Concrete Arch	1911	Luten Bridge Company
		13-29-2.58	Concrete Arch	1911	Luten Bridge Company
		13-66-1.49	Concrete Arch	1913	Unknown
		13-25-9.83	Concrete Arch	1913	Luten Bridge Company
		13-50-2.43	Pratt Through	1884	King Iron Bridge Co.
0	McDowell	None			
0	Mercer	None			
0	Monroe	None			
0	Nicholas	None			
0	Raleigh	None			
0	Summers	None			
1	Wyoming	55-14-0.01	Concrete Arch (open spandrel)	1917	Conc. Steel Br. Co.

DISTRICT FOUR

NO./ COUNTY	COUNTY	BRIDGE #	TYPE	DATE	BUILDER
5	Barbour	1-11-2.49	Camelback	1909	Merydith Bridge Co.
		1-40-5.17	Pratt Through	1886	Mt. Vernon Br. Co.
		1-11-16.00	Warren Pony	1905	Toledo Masillon Bridge Company
		1-1-3.64	Concrete Arch	1913	Luten Bridge Company
		1-10-9.94	Concrete Arch	1912	Luten Bridge Company
1	Doddridge	9-52-5.02	Pratt Pony	1892	Groton Br. Co.
4	Harrison	17-3/13-0.01	Warren Pony	1885	Marion Mach. Works
		17-19/18-3.71	Pratt Through	1889	King Iron Bridge Co.
		17-24/1-5.79	Concrete Arch	1914	Luten Bridge Co.
		17-42-1.0-6	Concrete Arch	1913	York Br. Co.
1	Lewis	21-119/16-0.29	Concrete Arch	1912	Luten Bridge Company
1	Marion	25-73/16-0.01	Pratt Pony	1888	Beeson & Helmick
1	Monongalia	31-37/7-1.53	Pratt Pony	1882	Marion Mach. Works
4	Preston	39-8/4-0.17	Pratt Through	1884	Unknown
		39-92/14-1.69	Pratt Through	1889	King Iron Br. Co.
		39-4/2-1.71	Pratt Pony	1893	King Iron Br. Co.
		39-39/1-0.01	Concrete Arch	Unknown	Luten Bridge Company
1	Taylor	46-54/1-0.01	Pratt Through	1894	Champion Br. Co.
4	Upshur	49-32-5.33	Pratt Through	1892	Pittsburgh Br
		49-30-10.18	Pratt Through	1897	Canton Br. Co.
		*49-13-1.57 &	Pratt Through	1902	Canton Bridge Co.
		*49-13-2.67	Pratt Through	1896	Canton Bridge Co.

*Previously nominated or determined eligible for the National Register.

DISTRICT FIVE

NO./ COUNTY	COUNTY	BRIDGE #	TYPE	DATE	BUILDER
0	Berkeley	None			
1	Grant	12-2-3.61	Pratt Through	1897	Youngstown Steel Bridge Company
0	Hampshire	None			
1	Hardy	*16-13-0.60	Pratt Through	1891	Youngstown Steel Bridge Company
1	Jefferson	19-1/9-0.65	Pratt Through	1889	King Iron Br. Co.
1	Mineral	29-16-5.80	Pratt Through	1891	Wrought Iron Br. Co.
0	Morgan	None			
0	Pendleton	None			
1	Pocahontas	38-219/5-0.01	Concrete Arch	1912	Luten Bridge Co.
1	Randolph	42-9/3-0.02	Concrete Arch	1914	Farris Br. Co.
2	Tucker	47-1-0.48	Baltimore	1896	W.Va. Bridge Works
		47-5-0.08	Pratt Through	1893	Canton Br. Co.
0	Webster	None			

DISTRICT SIX

NO./ COUNTY	COUNTY	BRIDGE #	TYPE	DATE	BUILDER
1	Brooke	5-32-2.36	Pratt Pony	1905	W.Va. Bridge Works
1	Hancock	15-11/5-0.01	Concrete Arch	1912	Unknown
0	Marshall	None			
2	Ohio	35-2505-0.57	Stone Arch	1892	Paige Carey Co.
		35-40-0.00	Camelback	1893	Wrought Iron Br. Co.

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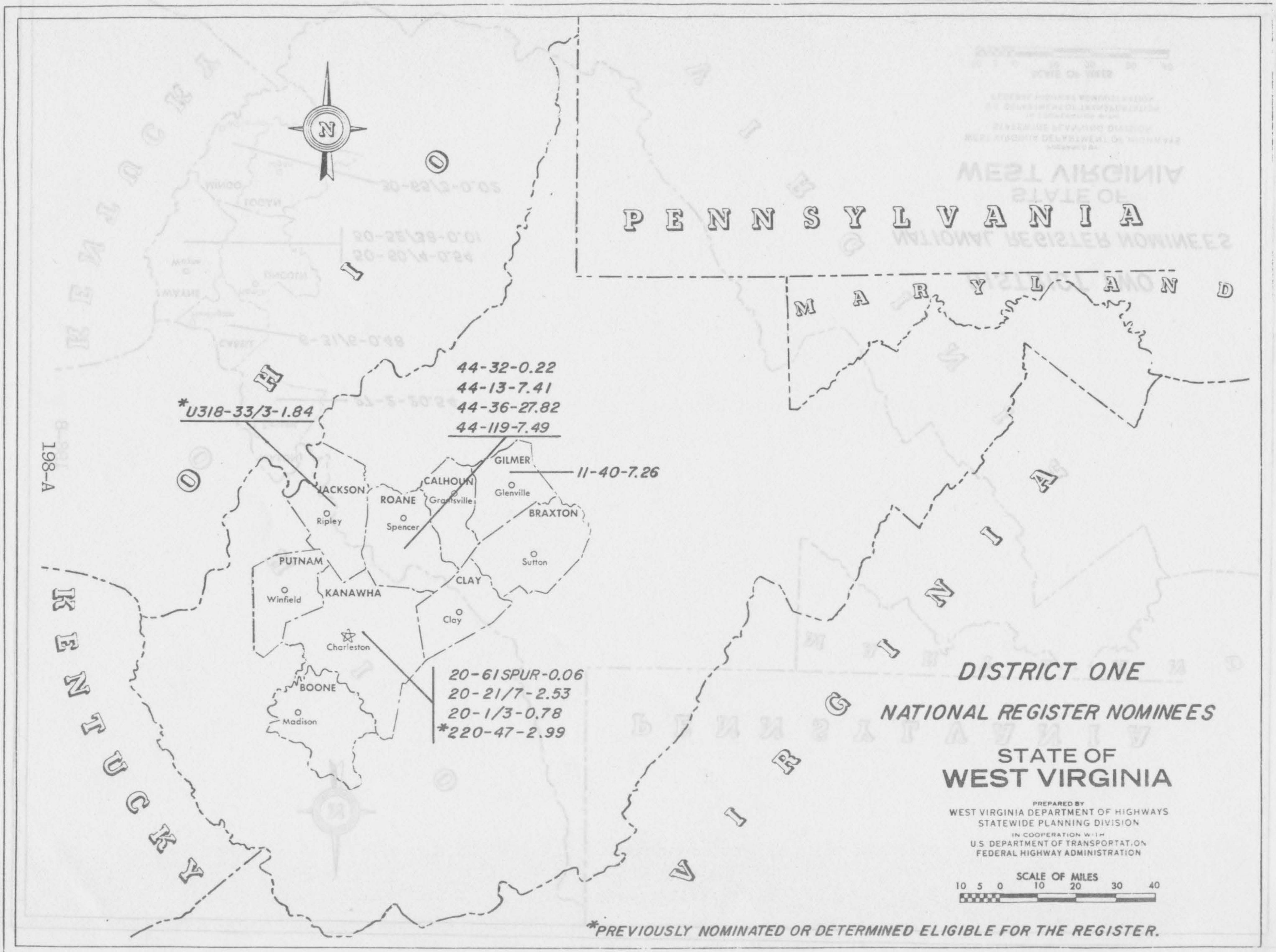
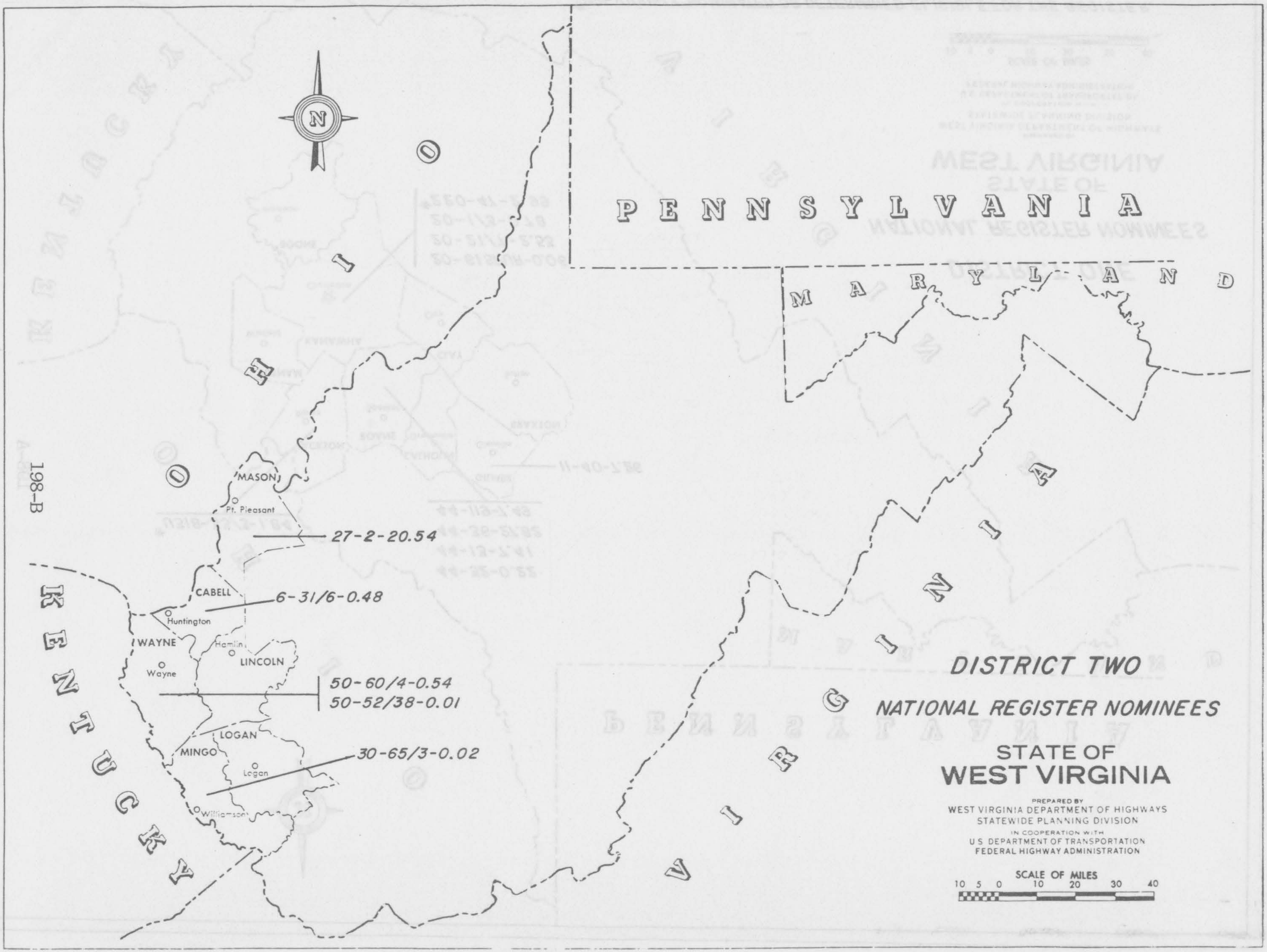
* Previously nominated or determined eligible for the National Register.

NO./ COUNTY	COUNTY	BRIDGE #	TYPE	DATE	BUILDER
1	Pleasants	37-3/8-0.76	Pratt Through	1894	Canton Bridge Company
5	Ritchie	43-5-5.19	Camelback	1900	Brackett Br. Co.
		43-7/18-4.93	Pratt Through	1898	Brackett Br. Co.
		43-50/4-1.25	Pratt Pony	1889	Unknown
		43-13-0.01	Concrete Beam	1914	J.T. Reaves & A.O. Wilson
		43-17/8-0.02	Concrete Arch	1916	Garrison & Douglas
1	Tyler	48-6-9.98	Pratt Pony	1887	King Iron Br. Co.
0	Wetzel	None			
0	Wirt	None			
4	Wood	54-14-26.84	Cantilever Truss	1903	Ohio River Br. & Ferry Co.
		54-14A-1.56	Camelback	1907	Unknown
		54-11-0.93	Pratt Through	1884	Lomas Forge & Br. Co.
		54-21/24-3.19	Pratt Through	1888	Lomas Forge & Br. Co.



DISTRICT ONE
NATIONAL REGISTER NOMINEES
STATE OF
WEST VIRGINIA
PREPARED BY
WEST VIRGINIA DEPARTMENT OF HIGHWAYS
STATEWIDE PLANNING DIVISION
IN COOPERATION WITH
U.S. DEPARTMENT OF TRANSPORTATION
FEDERAL HIGHWAY ADMINISTRATION
SCALE OF MILES
10 5 0 10 20 30 40
PENNSYLVANIA
MARYLAND
OHIO
KENTUCKY
VIRGINIA
N
*U318-33/3-1.84
44-32-0.22
44-13-7.41
44-36-27.82
44-119-7.49
11-40-7.26
20-61SPUR-0.06
20-21/7-2.53
20-1/3-0.78
*220-47-2.99
JACKSON
Ripley
ROANE
Spencer
CALHOUN
Grantsville
GILMER
Glenville
BRAXTON
Sutton
PUTNAM
Winfield
KANAWHA
Charleston
CLAY
Clay
BOONE
Madison
*PREVIOUSLY NOMINATED OR DETERMINED ELIGIBLE FOR THE REGISTER.



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PENNSYLVANIA
MARYLAND
VIRGINIA
KENTUCKY
MASON
Pt. Pleasant
27-2-20.54
CABELL
Huntington
6-31/6-0.48
WAYNE
Wayne
Hamlin
LINCOLN
50-60/4-0.54
50-52/38-0.01
LOGAN
MINGO
Logan
30-65/3-0.02
Williamson
DISTRICT TWO
NATIONAL REGISTER NOMINEES
STATE OF
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FEDERAL HIGHWAY ADMINISTRATION
SCALE OF MILES
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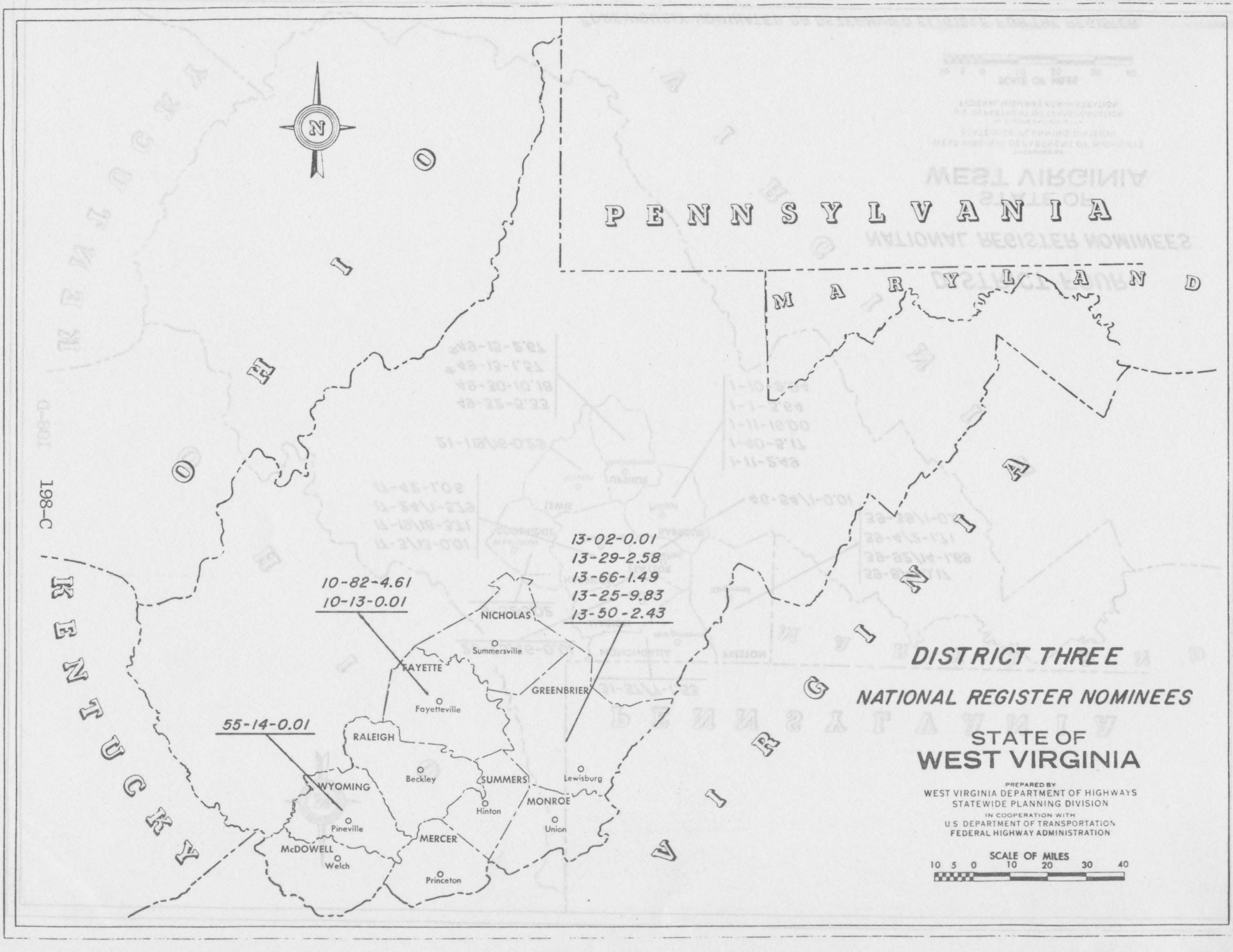
198-C
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VIRGINIA
KENTUCKY
10-82-4.61
10-13-0.01
13-02-0.01
13-29-2.58
13-66-1.49
13-25-9.83
13-50-2.43
55-14-0.01
NICHOLAS
Summersville
FAYETTE
Fayetteville
GREENBRIER
RALEIGH
Beckley
WYOMING
Pineville
SUMMERS
Hinton
Lewisburg
MONROE
Union
McDOWELL
Welch
MERCER
Princeton
DISTRICT THREE
NATIONAL REGISTER NOMINEES
STATE OF
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STATEWIDE PLANNING DIVISION
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U.S. DEPARTMENT OF TRANSPORTATION
FEDERAL HIGHWAY ADMINISTRATION
SCALE OF MILES
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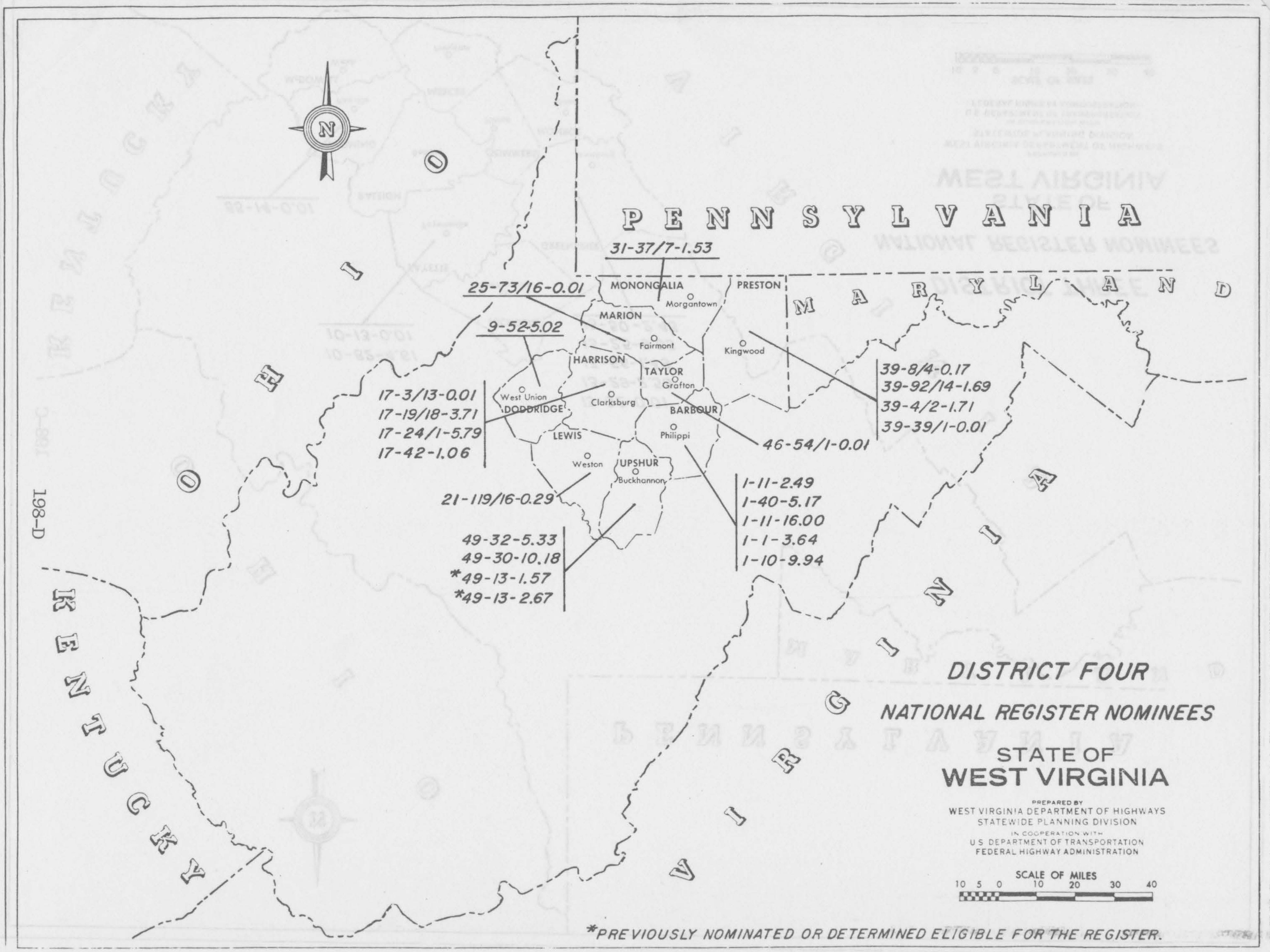

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MARYLAND
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VIRGINIA
MONONGALIA
PRESTON
MARION
HARRISON
TAYLOR
DODDRIDGE
BARBOUR
LEWIS
UPSHUR
Morgantown
Fairmont
Kingwood
Grafton
West Union
Clarksburg
Philippi
Weston
Buckhannon
31-37/7-1.53
25-73/16-0.01
9-52-5.02
17-3/13-0.01
17-19/18-3.71
17-24/1-5.79
17-42-1.06
39-8/4-0.17
39-92/14-1.69
39-4/2-1.71
39-39/1-0.01
46-54/1-0.01
1-11-2.49
1-40-5.17
1-11-16.00
1-1-3.64
1-10-9.94
21-119/16-0.29
49-32-5.33
49-30-10.18
*49-13-1.57
*49-13-2.67
198-D
DISTRICT FOUR
NATIONAL REGISTER NOMINEES
STATE OF
WEST VIRGINIA
PREPARED BY
WEST VIRGINIA DEPARTMENT OF HIGHWAYS
STATEWIDE PLANNING DIVISION
IN COOPERATION WITH
U S DEPARTMENT OF TRANSPORTATION
FEDERAL HIGHWAY ADMINISTRATION
SCALE OF MILES
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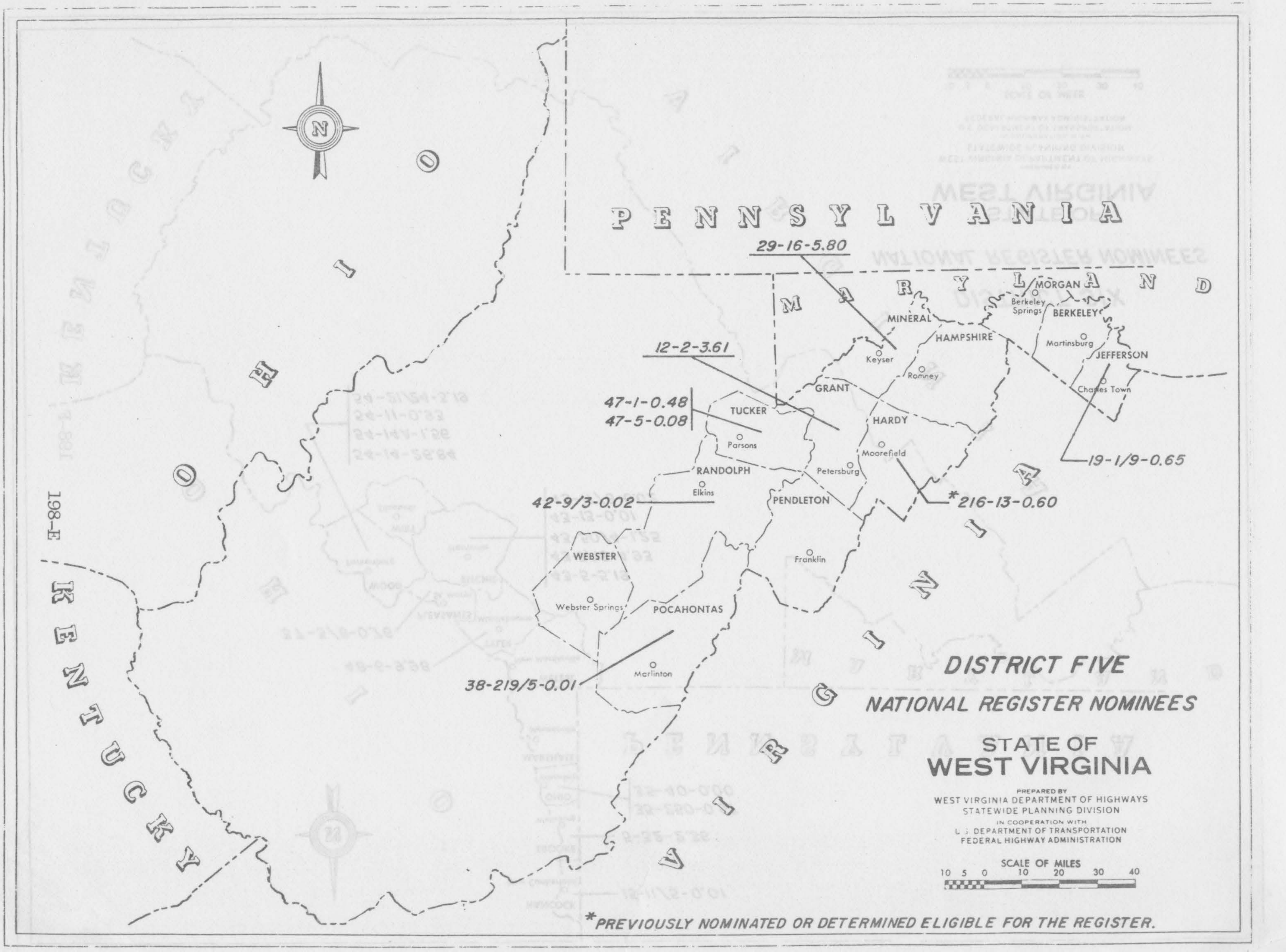
*PREVIOUSLY NOMINATED OR DETERMINED ELIGIBLE FOR THE REGISTER.


PENNSYLVANIA
MARYLAND
VIRGINIA
KENTUCKY
OHIO
N
198-E
29-16-5.80
12-2-3.61
47-1-0.48
47-5-0.08
42-9/3-0.02
38-219/5-0.01
19-1/9-0.65
*216-13-0.60
MORGAN
Berkeley Springs
BERKELEY
MINERAL
HAMPSHIRE
Martinsburg
JEFFERSON
Keyser
Romney
Charles Town
GRANT
TUCKER
HARDY
Parsons
Moorefield
RANDOLPH
Petersburg
Elkins
PENDLETON
Franklin
WEBSTER
Webster Springs
POCAHONTAS
Marlinton
DISTRICT FIVE
NATIONAL REGISTER NOMINEES
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FEDERAL HIGHWAY ADMINISTRATION
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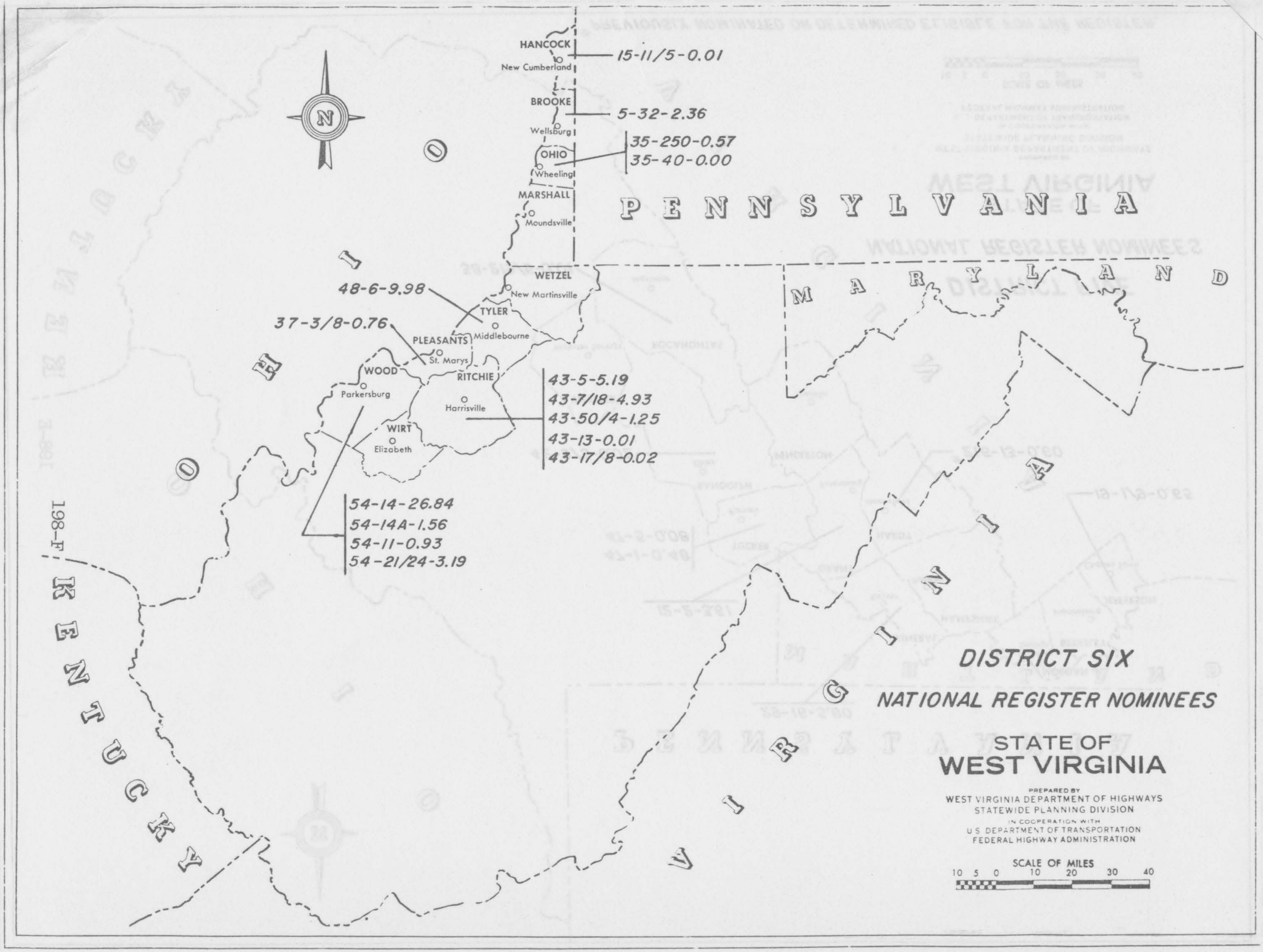
10 5 0 10 20 30 40
*PREVIOUSLY NOMINATED OR DETERMINED ELIGIBLE FOR THE REGISTER.



DISTRICT SIX

NATIONAL REGISTER NOMINEES

STATE OF WEST VIRGINIA

PREPARED BY
WEST VIRGINIA DEPARTMENT OF HIGHWAYS
STATEWIDE PLANNING DIVISION
IN COOPERATION WITH
U.S. DEPARTMENT OF TRANSPORTATION
FEDERAL HIGHWAY ADMINISTRATION

APPENDIX D
BRIDGE SUMMARY RATINGS

National Register Nominees

i.	From Rating Sheets	63
ii.	Bridges Previously Determined Eligible or Already Listed on the National Register (not included in Number One)	9
iii.	Covered Bridges on National Register	17
iv.	Wheeling Suspension Bridge (International Landmark)	1
	TOTAL	90

HISTORIC HIGHWAY BRIDGES IN WEST VIRGINIA

ALREADY ON NATIONAL REGISTER OF HISTORIC PLACES

Wheeling Suspension Bridge - National Historic Landmark
National Register of Historic Places
Nominee to World Heritage List

Covered Bridges of West Virginia Thematic Group (17 covered bridges)

Van Meter Stone Arch Bridge, Berkeley County

Helvetia Bridge (in Helvetia Historic District), Randolph County

Beverly Bridge (in Beverly Historic District), Randolph County

Elm Grove Stone Arch Bridge, Ohio County

OFFICIALLY DETERMINED TO BE ELIGIBLE FOR THE NATIONAL REGISTER

Post Mill Bridge #1, near Buckhannon, Upshur County

Post Mill Bridge #2, near Buckhannon, Upshur County

Silverton Bridge, Ravenswood vicinity, Jackson County

Elkview Bridge, Elkview, Kanawha County

Buzzard Ford Bridge, near Moorefield, Hardy County

APPENDIX E

MEMORANDUM OF AGREEMENT

THIS AGREEMENT, made and entered into this 21st day of March, 1984, by and between WEST VIRGINIA DEPARTMENT OF HIGHWAYS, a corporation, hereinafter called the Department, and WEST VIRGINIA DEPARTMENT OF CULTURE & HISTORY, hereinafter called Culture & History;

WITNESSETH

WHEREAS, the Department and Culture & History have participated in and approved a study entitled, "A Survey and Evaluation of Historic Bridges in West Virginia"; and,

WHEREAS, the Department and Culture & History have agreed that of the more than 4000 bridges surveyed, those with ratings of 30 or greater are eligible for the National Register of Historic Places, a preservation plan, attached hereto and made a part of this agreement, is adopted by the Department and Culture & History; and

WHEREAS, the Department and Culture & History have agreed that there are additional bridges which are not considered eligible for the National Register of Historic Places but have historical importance and are to be

evaluated according to the procedures outlined for these bridges labeled "Procedures for Group II Bridges" attached hereto and made a part of this Agreement; and

WHEREAS, the Department and Culture & History have agreed that the remainder of those 4000 or more bridges evaluated for historic significance which are not listed as eligible for the National Register of Historic Places (Group I) nor listed as historically important (Group II), have no historic affiliation and may be repaired, rehabilitated and/or replaced without further coordination with Culture & History.

NOW THEREFORE THIS AGREEMENT FURTHER WITNESSETH that for and in consideration of the premises and the mutual covenance herein contained, the parties hereto do further agree to abide by all the provisions of the Preservation Plan attached hereto and made a part of this agreement.

IN WITNESS WHEREOF, West Virginia Department of Highways, a corporation, has caused this Agreement to be signed by Charles L. Miller, its Commissioner, and its Corporate Seal to be affixed hereto by Philip A. Shucet, its Executive Secretary - Planning Manager, and in witness whereof West Virginia Department of Culture & History has

caused this Agreement to be signed by Norman L. Fagan, its Commissioner, and its Corporate Seal to be affixed by ____

____

________________________all thereunto fully authorized.

WEST VIRGINIA DEPARTMENT OF HIGHWAYS,
a corporation

by: ______________________
Charles L. Miller, Commissioner

ATTEST

____
Executive Secretary - Planning Manager

WEST VIRGINIA DEPARTMENT OF CULTURE & HISTORY

By: ______________________

ATTEST

____

APPROVED AS TO FORM THIS
12 DAY OF March, 1984
____
ATTORNEY LEGAL DIVISION,
WEST VIRGINIA DEPARTMENT
OF HIGHWAYS

PRESERVATION PLAN

An historic bridge survey was initiated by the Department of Highways and the Department of Culture & History to evaluate, categorize and rate highway bridges built prior to 1933 and owned by the West Virginia Department of Highways in order to determine eligibility for listing on the National Register of Historic Places (National Register). The survey was conducted by Dr. Emory Kemp of West Virginia University and financed by the Department of Highways, the Department of Culture & History and the Federal Highway Administration.

The following preservation plan was agreed upon and jointly adopted by the Department of Highways and the Department of Culture & History as a comprehensive and workable plan for those structures listed on the National Register as well as those structures considered historically important. The term "rehabilitation" in this Plan refers to work which will upgrade the structure without destroying the historic integrity of the bridge.

Group I Bridges

Once thematic nomination of the bridges eligible for the National Register (those rating 30 or above) is complete and accepted by the National Register, West Virginia will have __ bridges listed. Rated as the most historically significant in the state, these bridges were jointly selected by the Department of Highways and the Department of Culture & History to represent West Virginia's cultural and engineering achievements prior to 1933 and special efforts will be utilized to ensure preservation of these listed bridges. However, realizing future highway projects may involve replacement or rehabilitation of such a structure and/or an unforeseen circumstance may damage or destroy any of these structures, the Department of Highways and the

Department of Culture & History have adopted the following preservation plan for Group I and all bridges listed on the National Register.

A. The West Virginia Department of Highways agrees to:

1. Notify appropriate departmental personnel of bridges listed on the National Register and the efforts and attention which must be afforded them (preservation plan and interdepartmental procedures)

2. Notify the Department of Culture & History, Historic Preservation Unit, of any National Register bridge lost due to natural disaster, accident or any other unexpected occurrence

3. Coordinate with the Department of Culture & History, once a National Register bridge is programmed for rehabilitation, for review of and comment on the proposed work. Bridge plans and photographs, where appropriate, will be provided for review and comment and can serve as recordation for the proposed rehabilitation.

4. Perform a thorough analysis, including costs, for rehabilitation, replacement adjacent to the existing structure and moving the existing structure to a receiving location before a National Register bridge is replaced. This information will be submitted to the Department of Culture & History for review and comment. Replacement will only occur when (1) rehabilitation, building adjacent to the existing structure, repair and/or moving the existing structure

have been deemed infeasible and imprudent, or (2) replacement on new location causes severe adverse social, environmental and/or economic effects.

5. Provide the Department of Culture & History, for its review and comment, bridge plans and other pertinent information for any National Register bridge which must be replaced.

6. Provide appropriate drawings, photographs and salvage items as agreed upon to the Department of Culture & History for National Register bridges requiring replacement.

B. The West Virginia Department of Culture & History agrees to:

1. Nominate all (Group I) bridges (those rated 30 or above) to the National Register during calendar year 1984

2. Provide the West Virginia Department of Highways with a copy of the nomination forms, along with National Register acceptance (when received)

3. Review plans and appropriate reports submitted by the Department of Highways and respond within a reasonable time (30 days maximum) in order to ensure continual project development

4. Ensure that all original forms, negatives and related documents from the historic bridge survey are properly and permanently stored within the Historic Preservation Unit

5. Coordinate with the Department of Highways on all

nominations to the National Register (historic district, thematic, individual) which include highway bridges not identified in Group I for preservation

6. Provide the Department of Highways with copies of nomination forms and National Register acceptance or rejection for #5 above

C. Both parties agree:

1. That a meeting between both departments will be held on the first Monday in March, beginning in calendar year 1985 to decide the appropriate action to be taken for the periodic bridge inventory review which is to be done in a three-year cycle, beginning in 1985

2. That nothing in this plan precludes the Department of Highways from making emergency repairs to structures listed on the National Register

3. That nothing in this plan precludes the Department of Highways from performing routine maintenance, provided that routine maintenance does not significantly alter the factors which made the bridge eligible for the National Register

4. To consider public sentiment in making a decision for replacement or rehabilitation of these bridges.

Group II Bridges

Along with the bridges rated 30 or above (Group I) from the historic bridge survey, a second group of bridges rated between 25 and 29 has been identified. These bridges are not presently considered eligible for the National Register but do have some historic importance. They may be listed on

the National Register by (1) being located in an historic district listed on the National Register, (2) being the replacement for a Group I bridge requiring replacement, (3) being nominated by a local historic society or county landmarks commission or (4) if circumstances occur which changes a rating during the periodic review.

A. The West Virginia Department of Highways agrees to:

1. Coordinate with the Department of Culture & History when rehabilitation or replacement is necessary

2. Coordinate with the Department of Culture & History when replacement is necessary in order to determine the level of documentation necessary for recordation

B. The Department of Culture & History agrees to:

1. Coordinate with the Department of Highways and reply to A.1. and A.2. (above) within 30 days

2. Maintain a list of cities, parks, agencies, museums, etc., interested in obtaining an historic bridge for limited or non-vehicular use for Group II bridges (as well as those listed on the National Register) requiring replacement. If it is economically and structurally feasible to move the bridge to a new location, the Department of Culture & History will assist interested parties or agencies in identifying and contacting potential funding or volunteer sources for assistance in the relocation.

C. Both parties agree:

1. That nothing in this plan precludes the Department of Highways from making emergency repairs.

2. That nothing in this plan precludes the Department of Highways from performing routine maintenance.

WEST VIRGINIA DEPARTMENT OF HIGHWAYS

1900 Washington Street, East
Charleston, West Virginia
25305

John D. Rockefeller IV
GOVERNOR

Fred VanKirk
STATE HIGHWAY ENGINEER
ACTING COMMISSIONER

November 13, 1984

TO WHOM IT MAY CONCERN:

We have recently completed our historic bridge survey in West Virginia and are enclosing one copy of the final report for your information and use.

The survey was conducted by Dr. Emory Kemp as a joint venture between the West Virginia Department of Highways, West Virginia Culture and History and the Federal Highway Administration.

We are proud of the final product and look forward to sharing it with others.

Sincerely yours,

Fred VanKirk
State Highway Engineer-
Acting Commissioner

By: Ph. Shucet

Philip A. Shucet
Executive Secretary-
Planning Manager

PAS:Zs

Enclosure